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MEMOIR

OF

THEODORE STRONG.

1790-1869.

BY

JOSEPH P. BRADLEY.

READ BEFORE THE NATIONAL ACADEMY, APRIL 17, 1879.

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BIOGRAPHICAL MEMOIR OF THEODORE STRONG.

Theodore Strong, one of the original corporate members of this Academy, was born on the 26th day of July, 1790, and died on the first day of February, 1869, in the seventy-ninth year of his age. His birth took place at South Hadley, Massachusetts, at the house of his uncle, Col. Benjamin Ruggles Woodbridge, a prominent citizen of that place, who virtually adopted him as his own son. His father and grandfather both bore the name of Joseph Strong, and were Congregational ministers, descended from Elder John Strong, of Northampton, whose descendants, generally worthy of their Puritan ancestry, are scattered all over the land, and often found, as they have ever been, occupying positions of trust and responsibility. One of them is at this moment an honored associate of my own on the bench of the Supreme Court, being in the same degree of descent as the subject of this memoir, namely, the sixth degree from their common ancestor.

From this respectable lineage Theodore Strong inherited his vigorous constitution, as well as those solid elements of character which made him as eminent in purity and honor as he became in the walks of science.

His mother was Sophia Woodbridge, daughter of Rev. John Woodbridge, of South Hadley, the ninth generation of a succession of ministers bearing the same name, so that, on either side, Theodore Strong came from genuine Puritan stock. His ancestor John Strong was one of the first settlers of Dorchester, in 1630; and his ancestor John Woodbridge came to Massachusetts in 1634, and, returning to England, became one of the two thousand ejected ministers soon after the restoration of Charles II, and returned to this country as his permanent home in 1663. It is said of Theodore Strong's mother, Sophia Woodbridge, that she was a woman of very superior natural abilities, especially of the argumentative kind, and that in her younger days she was exceedingly beautiful. Men so

often inherit from their mothers their strong and healthy intellects and powers of reasoning that it has almost come to be a maxim of human experience that a man gets his mental ability from his mother. But Professor Strong's father is also said to have been a man of great energy, piety, and perseverance; but being blessed, like all of his ancestors, with a large family, he was not unwilling to permit his brother-in-law, Col. Woodbridge, who had no family of his own, to adopt his young son, Theodore, and take the responsibility of his bringing up and education. So it happened that the boy spent his early days in that beautiful region of mountain and farms where he was born. Of course he was early sent to school, where the spirit of emulation was first excited in him by a bright-eyed girl, who persisted in getting to the head of her class. Which of us has not had that same experience? At a proper age his uncle sent him to prepare for college with a neighboring clergyman, with whom he learned more accidence than he did arithmetic or algebra. At the age of eighteen he entered Yale College, then presided over by Dr. Dwight, the mathematical chair being occupied by Jeremiah Day, the chemical by Benjamin Silliman, and that of the learned languages by James L. Kingsley, with all of whom it became his good fortune to form associations of the greatest mutual respect and friendship. For the memory of President Dwight, in particular, he always retained the profoundest veneration. It was President Dwight, as he often remarked, who first taught him to think; and he was especially wont to speak of the benefit he received from the debates of the senior class held in Dr. Dwight's presence, and stimulated and guided into higher reaches of thought by his pungent questions and observations. "I could feel my mind *stretching*," he would say, "under the influence of Dr. Dwight."

Young Strong entered the freshman class very well prepared in the languages, but not much advanced in mathematics. At one of the earliest recitations in this department he made a failure, and was rather rudely laughed at by one of the class, which so excited his indignation that he turned to the offender, and, forgetting the proprieties of the place, said to him, quite audibly, "I'll teach you that I know as much about mathematics as you do!" From that moment he made up his mind to excel in that branch of study, and he kept his word to such purpose that when he graduated in 1812 he took the mathematical prize, and had already acquired such proficiency in the science as to attract the attention and friendship

of his teacher, Professor Day. His other studies had not been neglected, and he had become so deeply interested in Professor Silliman's department that at this period he formed the intention of pursuing the positive sciences, and especially chemistry. But it so happened that, shortly after his return home, Hamilton College, located at Clinton, in the State of New York, was in need of a mathematical tutor, and Dr. Azel Backus, the president of that institution, wrote to Dr. Dwight to inquire if any of the recently graduated class could be recommended for the position. Dr. Dwight unhesitatingly recommended Theodore Strong, and he was immediately appointed, and accepted the place. He remained at Hamilton College as tutor of mathematics for four years, and after that as professor of mathematics and natural philosophy for eleven years longer, and during that period laid the foundation of those profound acquirements in pure science which gave him such a high reputation amongst those engaged in similar pursuits throughout the country.

Thus, accident, in this instance, as in ten thousand others—or, at least, what appears to us as accident—cast the die which gave direction to a long and eminent life. Given a certain volume of brain and favorable circumstances for its development, and, from the observation I have made, I am convinced that the attainment of eminence in any particular department of science, or of active life, depends not so much upon any natural gift or aptitude therefor as upon other second causes, operating to lead the attention and energies in a particular direction. Men may be born poets or artists; that is, provided they cultivate poetry or art. For even here cultivation and practice are essential.

"For a good poet's made as well as born."

But in the special and particular development of the intellectual faculty I am sure that more depends on opportunity or chance than on any native genius or bent for a particular pursuit. Brain and opportunity are the factors of life. Nothing can be done without brain, of course, and nothing worth remembering without massive brain. But, given that, opportunity, often accidental in its character, does the rest.

Being a minute too late for the steamboat on the way to the metropolis to seek one's fortune may change the whole course of life; may lead to the college and the forum instead of the counting-

house and the exchange, and make a man to become what he never thought or dreamed of becoming. I have known just such a case. One man becomes an eminent divine instead of a lawyer; another an eminent mathematician instead of a merchant. Opportunity, accident, decided which it should be. Theodore Strong had brain, and a good store of it, and was, therefore, of capacity to become whatever Opportunity should set him to try for. She set him at mathematics, and he became a great mathematician.

When he received the invitation to the tutorship of Hamilton College he hesitated about burying himself in what was then regarded as the "Far West." But his uncle, who seems to have been a man of strong sense, and who undoubtedly exercised an indelible influence on his character, said to him: "Theodore, I have given you an education; now go forward and make a man of yourself!" He accordingly went; and perhaps the opportunities which he enjoyed for study and original investigation in that young institution were more favorable to his advancement in solid proficiency than a like position would have been in Yale, with its army of students and consequent tax on his time. Professor Day, in a letter addressed to him in December, 1813, says: "I have received yours of 15th November, and thank you for the communication of your ingenious discovery and demonstration of a property of the circle which I do not recollect to have seen in any author. I shall be gratified to hear from you frequently, and to learn from time to time what progress you are making in mathematical discoveries. I am very glad to see you placed in a situation where you have opportunity for investigation in your favorite science. I wish I had myself more leisure to devote to the higher departments of science. But as I am now situated I can do little more than endeavor to render truths long since discovered intelligible to those whom I am bound to instruct." The discovery and demonstration referred to by Professor Day were probably the demonstrations made by the young tutor about this time of the celebrated theorems respecting the circle, which had been propounded as a challenge to the world by Dr. Matthew Stewart in 1746. No demonstration had appeared until Mr. James Glennie, nearly sixty years afterwards, printed one in the Edinburgh Philosophical Transactions; but it is not probable that this had ever been seen by Mr. Strong. His attention was called to these theorems by one of the professors of Hamilton College soon after his going to Clinton. They had been recently published in

the 8th volume of Rees' Cyclopedia (article "Circle"), which was just being reissued in Philadelphia. In the then state of mathematical science in this country the demonstration of these theorems was undoubtedly a great feat of mathematical skill, which at once gave young Strong a very high reputation. It was sought for publication in the Memoirs of the Connecticut Academy. Professor Day, in a letter to Mr. Strong dated in August, 1816, says: "Your very ingenious demonstration of Stewart's propositions will be one of the most important papers."

A new and very neat and beautiful geometrical demonstration of the values of the sines and cosines of the sum and difference of two arcs, together with the solution of a difficult diophantine problem, was communicated by Mr. Strong to the first volume of Silliman's American Journal of Science, published in 1818. To the subsequent volumes of this journal he made a number of important contributions. One of these, in the second volume, contained the solution of a series of problems requiring the construction of a circle that should pass through given points and touch given straight lines or other circles, all solved in a geometrical way.

But having fully mastered the Newtonian Geometry as exhibited in the Principia and its commentators, he was now becoming deeply absorbed in the study of the higher analysis as developed by La Grange, Laplace, and other great mathematicians of the continent. To accomplish his purpose he resolutely set to work to learn the French language without the aid of a teacher, and became so well versed in it that he was able to read books pertaining to science as readily in French as in English. Whatever was necessary to be known in order to obtain a thorough comprehension of his chosen department he sedulously learned, stopping at no pains or trouble. Very few books in foreign languages were to be procured at that time without directly importing them. He accordingly imported such as were necessary for the prosecution of his studies, and when procured they were devoured with an appetite and digestion which made them a portion of his mental self. The science of mathematics to its profoundest depths was not merely acquired; it was absorbed into his being. He had no occasion to remember it; he knew it; not only in one relation and form of statement, but in all relations and forms. This was one of the peculiar features of his mental character, and lay at the basis of his real greatness as a mathematician, and at the same time explains some defects

of arrangement in his compositions, which will be adverted to hereafter.

In September, 1818, Professor Strong was married to Miss Lucy Dix, daughter of Captain John Dix, of Boston, a woman in every way worthy of him both in intellectual and moral accomplishments. An old friend whom he left behind at Yale, the brilliant and accomplished Professor A. W. Fisher (who afterwards met an early death whilst crossing the Atlantic), in a letter written at this time, rallied him in this wise on his newly assumed relations: "Matrimony and mathematics, I trust, in your hands will not get into a quarrel, as they have done in some cases. Newton, it seems, did not see how they could be made to agree; but the disciple of Newton appears resolved at least in making the experiment. May success attend him." And success did attend him. The lady whom he married was a woman of strong intellect and great good sense, and, instead of adding to her husband's burdens and interfering with his studies, relieved him in great measure from the detail of domestic cares, and by assuming them herself left him at leisure to pursue his favorite investigations without interruption or distraction. It is a happy lot when two persons of congenial dispositions are thus united; concurring harmoniously in the objects and duties of life, happy in each other, and contributing to each other's advancement in honor and usefulness.

Seven children were the result of this union, two sons and five daughters, one of the latter dying in infancy.

One of his daughters, the accomplished wife of the Hon. John W. Ferdon, at present a representative in Congress from the State of New York, gives this account of her father's mode of life and relations with his associate professors during the period of his connection with Hamilton College: "This period may be looked upon as the happiest portion of my father's life. The president of the college, Rev. Azel Backus, was a man of brilliant parts and of a most genial nature, and the professors generally were men of high attainments and ready sympathies. A most delightful fellowship prevailed among them. There was a great deal of what is called *esprit du corps*, and each man looked upon his associates' honor as his own. At this time the attention of scientific men was called to my father by his solution of several difficult mathematical problems. His correspondence also with scientific men was voluminous.

Letters dated at that time give us the best thoughts of such men as Silliman, Day, Fisher, and Olmstead."

Besides these more intimate associates and friends, Professor Strong early formed the acquaintance, either personally or by correspondence, of the most eminent men addicted to pure science on this side of the Atlantic, including Dr. Nathaniel Bowditch and Dr. Robert Adrain, and others of like proclivities and pursuits. The marriage also of one of his sisters to Dr. Benjamin W. Dwight, a son of President Dwight, and of another sister to Professor Charles Avery brought him into direct relations with men who could appreciate his worth and sympathize with him in his scientific inquiries. From one of his nephews, Rev. Benjamin W. Dwight, of Clinton, many valuable hints have been derived in the preparation of this memoir.

In 1825 and 1826 Professor Strong's increasing reputation was such that he received invitations to accept the chair of mathematics in Queens (afterwards Rutgers) College, in New Jersey, in Columbia College, New York, and in the University of Pennsylvania, all of which, however, were for various reasons declined. In December, 1827, receiving a second invitation of the kind from Rutgers College, he concluded to accept it, and removed with his family to New Brunswick. I cannot forbear again quoting from his daughter's memorandum. She says: "The journey to New Brunswick, the seat of Rutgers College, occupied at that time about a week. Several days of the transit were spent in slowly voyaging through the Erie canal. The now venerable Thurlow Weed, then a rising politician and editor, was a fellow-passenger, and the writer was kindly seated upon his knee during a great part of the journey."

At New Brunswick Professor Strong spent the remainder of his long life. Here he continued to pursue those abstruse studies and profound investigations, of which the outside world only obtained occasional glimpses in the articles contributed to scientific journals or academic societies, until the publication of his work on Algebra in 1859. Here the writer of this paper enjoyed his instructions, and learned to reverence his character and admire his great attainments. To give an idea of the manner of his life I cannot do better than to quote again from the memorandum furnished by his daughter, who, as before seen, was but a child when the family removed to New Brunswick. She says: "My earliest recollections of my father are of a man generally grave, thoughtful, absorbed in

his studies, yet occasionally unbending and engaging in frolic with us like a boy. He visited neighbors very rarely, and, except during his daily morning walk and hours of college duty, was generally found at home, always with book in hand. He was never annoyed by unfavorable surroundings, but would often sit in my mother's room, when his children were all at play around him, and enjoy with his book as complete abstraction of mind from all passing events as if he was alone in the universe. His table talk, however, is what I recall with most pleasure. All the phenomena of nature, as observable in passing events, were pointed out to our childish minds, and the question, Why these things were so? propounded to set our faculties at work—as, for instance, the condensation of vapor on our glasses in hot weather; how flies could walk on the ceiling, and many other questions of like nature; the derivations of the words we used also—which were from the Latin, which from the Greek, &c. He personally superintended our education, none of his daughters being sent to school for any length of time. In addition to his other duties he found time to instruct us in Latin, astronomy, and mathematics, and to require us to read aloud to him leading books of history, geology, and similar topics. He believed in the thorough education of woman, and I think it was a source of deep regret to him that none of his daughters gave any promise of emulating the fame of Mrs. Mary Somerville, whom he often spoke of as an example of what woman may achieve in the domain of science. As I grew older, and observed more particularly the books he read, I noticed that, though he found or made time for the perusal of general literature, with which he was remarkably conversant, yet his hours of deepest intellectual delight were found in the perusal of the works of Laplace, Newton, La Grange, and Plana. His life, thus to the busy world seemingly uneventful, glided away in the fulfillment of the duties of his position, the pursuit of knowledge, and the enjoyment of intercourse with men of science, many of whom came to consult him on points interesting to mathematicians."

The testimony of one of his intimate associates in professorial labor at this period is apposite here. Speaking of Professor Strong's breadth of culture, he says: "His love of books, and of a retired and contemplative life, enabled him to range over a wide and various field of knowledge. He 'sought and intermeddled in all wisdom.' He was largely read in history, in mental philosophy, in theology.

Among books it might perhaps be said that Bacon, Butler, Jonathan Edwards, and Dwight were his favorites. He cited occasionally, in conversation, those works of Bacon which are now rarely looked into. Bishop Butler's Analogy was his special delight. The suggestive—I had almost said hypothetical—way in which that great writer propounds truth made, he said, a deeper impression on his mind than the most vehement positive utterances. He had examined, with conscientious care and wide breadth of research, the evidences of Christianity. The question, What is truth?—in its relations to God and the soul—stirred his mind profoundly. His mental constitution and habits forbade him to yield his assent on any subject without sufficient evidence. His inquiries in this direction had resulted in a deeply-grounded and reverential faith."

Professor Strong's method of study, and that which he often impressed upon his pupils, was to study subjects rather than implicitly to follow books. In his case, as before remarked, it resulted in a complete absorption into his intellectual being of that which he attempted to master. With his strong and comprehensive intellectual grasp he seemed to arrive at results by intuition. In ordinary cases he could hardly have been conscious of the mental process by which his conclusions were reached. As all the propositions of mathematics are equally true and equally obvious to one who has a perfect comprehension of them, it necessarily follows that one who, like Professor Strong, sees each truth with equal clearness will scarcely note the progressive stages by which other minds, less gifted or less informed, are obliged to advance step by step in order to comprehend the more abstruse conclusions of the science. Hence it often occurred in his recitations that he would unconsciously get far ahead of his auditors, and much beyond their depth, until recalled to the actual situation of affairs by some question put by them or by himself which brought to his attention the distance which they had been left behind. This fact often produced the impression that he was not a successful teacher. But those who had in any degree a mathematical sense were well compensated by the striking originality of his views and the vivid light in which he often placed the subject under discussion. In his own mind his deductions were as clear as sunlight, and he made the scholar see them in the same way if he saw them at all. To those who had any taste for mathematical investigation he was a teacher to be desired; to those who had no taste for it he was sometimes unintelligible.

And yet it was astonishing with what perfect simplicity and clearness he would often render a profound truth, and all because it was so clear and simple to himself.

Perhaps it is often the case that the most successful teachers for the ordinary class of pupils, who require that the truths of science should be forced into them by extraneous aid, are those who have had to labor hard themselves to acquire those truths—men of slow parts, and at the same time solid understandings. They know the hard places. They can tell to a dot where it is and what it is that perplexes the young mind. They know just how to lead it step by step; just where to hold the lantern to it to enable it to pass smoothly and successfully over difficulties. In this there may be something due to natural tact; but I am inclined to think that this tact which we call natural is often the result of the teacher's own dear-bought experience. If it be true that this class makes the most successful teachers, taking the pupil world as it is, by and large, why, then, Professor Strong did not belong to it. He had marched with giant strides over the road which the student was obliged to creep.

But in speaking of the professor's unconscious tendency to diverge into regions where the ordinary student could not well follow him, it is but just to say that nothing gave him greater delight than to aid and assist those who seemed really desirous to learn; and in such cases he would spare no pains to simplify the subject under discussion, and set no limit to his patience in trying to remove every obscurity which beclouded the apprehension of the inquirers. His uniform condescension and kindness in this regard always won affection and respect, even from those who profited least by his instructions. Moreover, the remarks just made have reference only to the department of pure mathematics. In that of natural philosophy Professor Strong's teachings were most interesting and attractive, and always adapted to an ordinary capacity. Here, as in mathematics, he was profoundly master of his subject, which, having relation to the concrete manifestations of the natural world, he presented with such simplicity and familiarity of illustration that it was indeed a pleasure to listen to him, and the recitations were looked forward to with delightful anticipation.

I have often thought that it must be a most irksome task to a man of real ability and genius to be obliged, as many such men are, and as we have seen President Day complaining that he was,

to wear away their manly years in teaching, going over and over again the same course of mere elements, and endeavoring to inculcate them into just-dawning intellects. It is a great and a noble duty, to be sure, and its successful performance is attended with some consolations; but I apprehend that the greatest consolation which it affords is found in the leisure and opportunities which it often gives for pursuing, aside, the higher departments of science, and finding sympathy in that brotherhood of learned men whose silent and unpretending researches shed the richest lustre on any country.

Necessarily dry as were some of the subjects which Professor Strong was assigned to teach, he never forgot his responsibility to his pupils as a man and a Christian. Many an opportunity occurred, of which he failed not to avail himself, by a sententious or impressive remark, to fix in the minds of the young men around him those fundamental truths and principles which form the only true basis of character, happiness, and success in life. His solid sense and known worth were such, and his manner so unaffected and sincere, that no labored homilies could have produced so good an effect. He despised all sham and pretence. The coxcombry of prurient free-thinking in religion or morals was his detestation. Many a sturdy blow was given to these evil demons in a sentence or two of hard, New England sense—sentences which sank deep into the minds of the listeners and are still remembered, or have their effects to this day. Observations on the ordinary conduct of life were not omitted; sometimes serious, sometimes amusing or satirical, always sensible and just. Physical geography was at one time a branch of study on which he was required to give some lectures, involving to some extent the natural history of different regions. One day the subject of discussion somehow brought up the question of development of species and varieties, and thence led to the effect of breed and blood in horses and other animals. Suddenly, looking around at the class with great seriousness, he said, in his deep, bass tones, "Gentlemen, there is a great deal in this matter of blood. You will soon be thinking of marrying and settling in life. Much of a man's happiness and success depends on his choice of a partner. My advice to you is look to the blood; there is a great deal in blood!" and then he quietly proceeded with the recitation. This is but a slight illustration of the manner in which he would interject remarks on subjects of practical interest as well as on those of a higher nature.

Of course they were often expanded into forms of rich and earnest thought, which never failed to produce a deep and lasting impression.

The amount of influence which such a man exerts through a long life upon the successive classes of young men that come in contact with him, and through them upon society and those who give it tone and power, cannot well be computed.

Age, however, began to creep apace upon the good professor, and in 1859 the trustees of the college, probably somewhat influenced by the impression alluded to in reference to the supposed deficiency of attractiveness in his method of teaching, deemed it advisable to appoint an associate professor in his department, thus relieving him to a large extent from active duty in the class-room. It was at this period that he brought out his work on Algebra. At the same time, feeling conscious that he was still in possession (as indeed he was) of all his intellectual powers, he did not submit kindly to what he deemed an attempt to ignore his usefulness. In 1861, now in his 72d year, he was relieved from active duty, and declared emeritus professor. In 1863 he resigned all connection with the institution, and passed the remainder of his life in the prosecution of his favorite investigations in analytical science, and in the enjoyment of that society of the learned dead and of the few remaining associates of his earlier years who yet survived, as well as in the respect and reverence of all who knew him and had learned to appreciate his great abilities and sterling character.

In 1859, as already stated, Professor Strong published his Treatise on Elementary and Higher Algebra, a work remarkable for its originality and depth. His treatise on the Differential and Integral Calculus was principally written in the summer of 1867, in the 78th year of his age, whilst on a visit to his nephew, Rev. B. W. Dwight, at Clinton, and was not published until after his death. Perhaps no other treatises on these subjects exhibit in an equal degree so much logical power and such profound acquaintance with fundamental principles. The student is conducted, often by fresh and untrodden paths, to the highest eminences of the science, and may always repose the utmost confidence in his leader's keenness of vision and sureness of foot hold. For notwithstanding Professor Strong's profound knowledge of his subject, and his immense learning, embracing, as it did, a thorough acquaintance with the whole body of mathematical science, both ancient and modern, and perfect famil-

iarity with all that had been written by Newton, La Grange, Laplace, Poisson, Ivory, Airy, Le Verrier, and others of like eminence and power, he was, nevertheless, always extremely cautious in accepting his own conclusions, and made it his habit carefully to review, over and over again, his demonstrations and solutions of problems, in order to be perfectly sure of their correctness before offering them to the inspection of others.

His arrangement, however, is not always the most happy for those whose knowledge is not considerably advanced, abstruse discussions, though logically consecutive to what precedes, being frequently introduced before a mere learner can be presumed qualified to comprehend their import. Thus, in the Algebra, after giving a lucid and masterly explication of the rules and principles of multiplication, he quietly proceeds to unfold the method of constructing equations by the multiplication of successive binomials, and does not leave the subject until the whole doctrine of the roots of equations is established—beautifully established, it is true, to those who are capable of following the discussion, but not discussed at a time when a beginner in the science would be likely to be edified. Another instance of the anticipation of abstruse inquiries is found in the section on Geometrical Proportions and Progressions, at the close of which the student will be surprised to find demonstrations of the theorems of Taylor and Maclaurin and of the principle of differential coefficients. Whilst these discussions are most satisfactory, and are, indeed, strictly algebraical, and whilst they show the marks of a great original mind, and possess the highest interest for those who are already proficient, or at least quite advanced, in analytical investigations; they are not well adapted to the comprehension of mere students in algebra. Perhaps it is but just to say, however, that this introduction of abstruse subjects should not be deemed irrelevant in a work which professes to treat as well of the higher as of the elementary parts of the science. But as such higher parts are only interesting to a chosen few, the effect is to load the book with too much weight for popular appreciation.

This defect of arrangement, or, if it be more proper to say, this introduction of abstruse, though perhaps necessary, discussion—necessary to a complete view of the subject in all its relations and adaptations—is probably the true reason why these works have not been appreciated by the public as their merits deserve. The work on Algebra not meeting with a ready sale, the whole edition, save a

few copies, was destroyed by the New York book-sellers into whose hands it fell after the failure of the publishers. Thus, from a want of ready appreciation, one of the most original and profound works on pure science which this country has ever produced has become so scarce that a copy is now hardly to be met with. Here and there an industrious investigator, who happens to possess one, will draw from it, as from a rich mine, things of beauty and value, which, garnished with new settings, will bring to the finder reputation and honor. If he happens to be a man of justice and candor he will award to his master that tardy recognition which alone is all that true greatness often receives in this world.

Whilst preparing his work on the Calculus, which he proposed to publish at his own expense, some friend expressed apprehension that, from the nature of the work, it would not be a pecuniary success, but money thrown away. His reply was characteristic. "No matter," said he, "it will be appreciated by posterity, and show at least that I have not lived in vain; and that is all I ask!"

Of these two works, the Algebra and the Calculus, it does not become me to speak in detail with any pretension of authority. As already stated they are not books for ordinary college students—they go too deep for that. But I think I am not mistaken in saying that no real student of analytical science, who desires to understand it in all its depth and power, can read these books without being greatly instructed and refreshed. For original investigation and profound knowledge of the subject they cannot be excelled. They certainly, also, contain many things entirely new in the sciences of which they treat. For example, the solution of Cardan's irreducible case of cubic equations in the Algebra has accomplished what the mathematical world had for centuries sought to accomplish in vain. Its practical value, however, since the elegant method discovered by Horner for solving all numerical equations, is not great. It involves the extraction of a number of successive square roots, which makes the operation somewhat tedious. But this does not derogate from the merit of Professor Strong in producing a rigidly logical solution, which had defied the efforts of all previous mathematicians.

In the able review of the Treatise on Algebra in Silliman's Journal for September, 1860, it is said "this work does not belong to the class of elementary compilations with which our schools and colleges are so abundantly supplied, but is a fresh and original

treatise, stamped on every page with the peculiar impress of the author's mind. It contains, moreover, several positive additions to the science, while many of the demonstrations of well-known propositions are new and highly suggestive." Again, "Dr. Strong has risen to such heights in the science, and has so long been an industrious explorer on its confines, that he has lost sight of the paths by which the novice must necessarily be introduced. But, assuming the reader to have acquired a fair knowledge of algebra, including the general theory of equations, we would recommend him to read this work as a *review*, in which the science is rearranged in a special order, and a new light is thereby thrown on many of its processes. For Dr. Strong is a master of his subject, and handles the most difficult parts of it with something of that giant ease which we feel and admire so much in the great Euler." And after discussing the new solution of the irreducible case of cubic equations he says: "This method, therefore, may be justly claimed as an addition to the science, as well as the solution of binomial equations, the new demonstration of the binomial theorem, the development of the roots of equations, series, etc.; all of which will be read with pleasure by advanced students."—(*Am. Jour.*, vol. xxx, p. 306.)

As it may be interesting to know what things in the Treatise on Algebra Dr. Strong himself regarded as new I shall here take the liberty of copying a statement on this subject furnished by him to an intimate friend interested in mathematical inquiries. Besides the solution of the irreducible case the following items are specified:

1st. A new and direct investigation of the binomial theorem. (Page 271, &c.)

2d. A new and very simple method of finding integral algebraic roots. (Page 284, art. 6.)

3d. A new and very simple proposition of great use in extracting the roots of quantities of the form $1 + \frac{b}{a}$, by resolving them into any number of factors of the like form. (Page 288, art. 8.)

4th. A new and very simple method of solving quadratic equations without the formality of completing the square. (Page 397, art. 2.)

5th. New formulas by which to solve equations by the immediate development of their roots without finding their first figures by trial, as is usually done. (Pages 439, 440, formulas (b) and (c).

6th. The doctrine of continued fractions deduced immediately

from the form of the quotients and remainders in common division. (Page 443, &c.)

7th. A new demonstration of the method used for finding the limits of the real roots of equations, including the theorem of Des Cartes. (Pages 471, 480.)

8th. A new method of developing the real and imaginary roots of equations. (Page 449, § 19.)

9th. A new and much more simple method than that of Sturm for finding the first figures of the real roots of an equation. (Page 512.)

10th. A new and simple method of resolving whole numbers into their factors. (Page 535, § 21.)

The late Professor De Morgan, of London, a high authority on such subjects, receiving a copy of the book, expressed himself in terms of admiration of its ingenuity and of the importance of some of the above improvements.

As to the work on the Calculus I can only say that the subject is investigated from its fundamental principles in such a thorough manner that no one can study the book without acquiring a better comprehension of the science than he ever had before. As has been justly observed, the processes of integration employed are so excellent in themselves, while being at the same time original, as to seem even elegant to a mathematical eye. The difficulties that had embarrassed the previous treatment of the first principles of the Differential Calculus are eliminated. The infinitesimal method of Leibnitz and the method of limiting ratios of Newton are shown to be unnecessary in a proper conception of the science. Of course in this general view Dr. Strong follows La Grange; but he demonstrates it in such an original way that it seems new, and makes the conclusion perfectly obvious and satisfactory. By an explanation of his own, which is purely algebraical, he divests the Calculus of all its old metaphysical incumbrances, which were the stumbling-blocks of so many ingenious minds. On page 266 is the solution by a new and beautiful method of the problem "to find the area bounded by the ordinate of a plain curve drawn through the origin of the co-ordinates, by any other ordinate, and the intercepted parts of the axis and the curve, supposing the ordinate to be constantly positive between the preceding limits"—being the same figure used by Newton to demonstrate his celebrated Lemmas, II, III, and IV. Having

solved this apparently innocent problem by a course of demonstrative reasoning, the author shows how it results in establishing the foundation principles of the Calculus without the intervention of any of those antiquated hypotheses to which we have referred. "It is hence clear," says he, "that the Differential and Integral Calculus are deducible from what has been done without using infinitesimals or limiting ratios." (Page 271.)

If we may believe those most competent to judge, the book is full of interesting discussions which, to one who is at all familiar with the ordinary modes of treating the subject, are as refreshing and exciting as it is to travel over a new country, which one has never visited before, and which is filled with picturesque objects and beautiful and varied scenery. To those who have no taste for analytical methods of investigation it is a sealed book; but to those who have such a taste, it is fraught with interest and instruction, in consequence of the fresh and original manner in which every subject is treated. It evidently flows from a mind full of the subject, and disdaining to copy from others where original treatment is capable of placing it in new and interesting lights.

As before remarked, Professor Strong was a contributor, during the greater portion of his active life, to various mathematical journals and to learned societies, of which he was a member. His solution of questions and his general discussion of subjects were always marked by profound knowledge of the subject in hand and a complete mastery of the best methods of treating them. Being one of the first in this country to acquire a thorough knowledge of analytical science as exhibited in the works of the mathematicians of France, Germany, and Italy, he brought to these solutions and discussions an ease, a generality, and a comprehensiveness which always excited the admiration of his colaborers. By the aid of a mathematical friend I am enabled to give a list of the principal journals in which these miscellaneous papers appeared. These are—

1. Silliman's American Journal of Science. Twenty-two papers of Professor Strong's are published in the first series of this journal, extending from 1818 to 1845.

2. The Mathematical Journal, published in New York, of which only one volume appeared.

3. The Scientific Journal, edited by Mr. Marrat, and published at Amboy, in monthly numbers, of which nine in all appeared in 1818 and 1819.

4. The Mathematical Diary, published at New York, and edited at first by Dr. Robert Adrain and afterwards by James Ryan.

5. The Mathematical Miscellany, edited by Mr. Charles Gill, at St. Paul's Collegiate Institute, Flushing, Long Island. There are twenty-two papers by Dr. Strong in this periodical. Mr. Gill subsequently became the eminent actuary of The Mutual Life Insurance Company of New York.

6. The Cambridge Miscellany, edited by Professors Peirce and Lovering. Seven of his papers are published in this periodical.

7. The Mathematical Monthly, edited by J. D. Runkle. Two of Dr. Strong's papers are published in this work.

Besides the above he made various communications to the Connecticut Academy, of which he was elected a member in 1815; to the American Philosophical Society, of which he was elected an honorary member in 1844, and probably to the American Academy of Arts and Sciences at Boston, of which he was also a member. He also communicated his solution of cubic equations to the Smithsonian Institution in 1849, which was not published at the time, in the hope, as Professor Henry wrote to him, that he would add to it some other papers, so as to make a more considerable article for the Contributions.

He also communicated five different papers to The National Academy of Sciences, from 1864 to 1867, inclusive.

No doubt many others could be found by a diligent search of the scientific journals published during the period of his active labors.

The papers published by him in Silliman's Journal are in the form of discussions of various subjects to which he was giving his particular attention at the time. Collected and arranged in the form of a book they would constitute a useful commentary on many difficult portions of the Mécanique Céleste and cognate works. These papers are characterized by the Professor's usual originality of treatment, and often throw important light on points that were left obscure by the great authors whose works he was studying. Dr. Bowditch's translation and commentary have undoubtedly supplied nearly all that is wanted to the proper understanding of the Mécanique Céleste; but it may well be supposed, as the fact undoubtedly is, that Professor Strong, whose study of Laplace's works had long preceded the publication of the translation, has often taken original and independent views which would greatly aid in a complete mastery of the whole range of subjects treated of.

I can here only give a list of the papers referred to, and specify the various subjects discussed. Besides the geometrical problems in the first and second volumes of the Journal, already mentioned, we have the following:

1. A new and entirely original demonstration of the binomial theorem, in volume 12, page 132.

2. A systematic discussion of the laws regulating the action of a central force, the path of the curve produced thereby, and the mutual action of a system of bodies. These papers, which constitute a valuable monograph on the subject of central forces, are twelve in number, and are contained in the 16th to the 26th volumes of the Journal.

In the course of this discussion, in volume XVI of the Journal, page 286, we find a beautiful deduction of the differential equation which constitutes the fundamental formula for expressing the angular velocity of a planet in terms of its radius vector, and thence, the force being given, the law of the curve of revolution, and of all curves produced by a central force, corresponding to the result given by Laplace in the first part of his 2d book of the Mécanique Céleste, Equation (3), and to that of Newton in the 41st proposition, section VIII, of the Principia. This, however, is but a single instance of many similar correspondences which illustrate and simplify the grand results established by these great masters of the science, sometimes with greater generality and comprehensiveness.

3. A discussion of the parallelogram of forces, their composition and resolution, and the statical equilibrium. Here we have the groundwork of a treatise on analytical mechanics. This is comprised in three separate papers contained in volumes 26, 28, and 29 of the Journal.

4. In volume 30 we have a paper on the variations of the arbitrary constants in elliptic motion.

5. In volume 42 we have a paper entitled "A new demonstration of the principle of virtual velocities," rewritten and inserted in an improved form in volume 43.

6. Volume 42 also contains a paper on the integration of a particular kind of differential equation of the second order—being a more general and more accurate integration than that given by La Croix of the same equation, and including a particular form of it, propounded in Prof. Peirce's Mathematical Miscellany.

7. In volume 45 there is a paper containing Remarks on the First

Principles of the Differential Calculus, together with a new investigation of Taylor's theorem.

8. Volume 48 contains a paper entitled "A new way of obtaining the exponential and logarithmic theorems"—which, as I remember, the Professor explained to us many years before when I was attending his lectures in Rutgers College.

The *Mathematical Diary* was commenced in 1825 and continued to 1832. It was conducted with much ability and was the vehicle of many difficult solutions of problems by the highest mathematical talent of this country. Its contributors, besides the learned editor, were Dr. Bowditch, Professor Strong, Professors Anderson, Quinby, Nulty, and others. A series of select questions were proposed in one number and answered in the next. Every successive number announced that all the questions had been solved by Dr. Bowditch and Professor Strong, sometimes one or two others being added. In most of the numbers some question of great difficulty would be proposed, called the prize question; and whoever, in the estimation of the editor, or of a committee taken into council on the subject, gave the most satisfactory and elegant solution, would take the prize, which was simply the honor of having the number containing the solution called by his name. The second number of the journal, containing such a solution by Dr. Bowditch, was called The Prize Number of Nathaniel Bowditch. The third number was called The Prize Number of Theodore Strong. And, by the way, the problem solved by him in this instance is one of the most difficult and elusive that can be attacked by the ordinary analytical processes. It is called the boat problem, and requires an investigation of the path that ought to be described by a boat in crossing a river of given width from a given point on one side to a given point on the other, so as to make the passage in the least time possible, supposing the simple velocity of the boat by the propelling power to be given, and that the velocity of the current, being in the same direction with the parallel sides of the river, is variable and expressed by any given function of the perpendicular distance from the side of the river from which the boat sets out. The curve required is analogous to the curve of pursuit described by a spider, starting at a given point within a circle, or in its circumference, and chasing a fly which starts at another given point of the circumference and follows it in a given ratio of speed to that of the spider. The solution of Professor Strong is most ingenious and satisfactory, and is

inserted by him in the appendix to his work on the Calculus, with a practical exemplification, by means of a figure, adapted to a particular case.

The *Mathematical Miscellany*, edited by Mr. Gill, except that it contained more discussions of a general character, was in most respects similar to the Diary, and was published twice a year, from 1836 to 1839, inclusive. Amongst its contributors were Professors Strong, Avery, Peirce, and Catlin. Some of the problems required in their solution the very highest range of mathematical skill, and, as in the Diary, the periodical announcements showed that solutions to all of them were furnished by Professor Strong, this distinction being shared by only one or two others. The sixth number contained a paper by him on the orthographic projection of the circle, which Professor Peirce characterized as "beautifully neat."

In the proceedings of the American Philosophical Society of Philadelphia for the year 1843 I find a short paper of Professor Strong's on Analytical Trigonometry, and in the same volume a paper on the transformation of the series, $S = ax + bx^2 + cx^3$, &c.

The papers communicated by him to the National Academy were, (1st), Notes on the parallelogram of forces and on virtual velocities, March, 1864; (2d), On the integration of differential equations of the first order and higher degrees, August, 1864; (3d), A new theory of the first principles of the differential calculus, August, 1865; (4th), A new theory of planetary motion, August, 1866; (5th), On a process of integration used in the case of a planet's orbit disturbed by small forces, August, 1867.

Of course, some of the subjects treated of in the foregoing list are again discussed in the Algebra or the Calculus, but never, or rarely, in the same form; for, as before stated, the truths of mathematical science lay in Professor Strong's own mind, ready to be drawn out in original forms, and he rarely copied, even from himself, but relied on the resources of his own intellect.

Thus, in the brief memorial furnished by his nephew, Rev. B. W. Dwight, I find the following interesting account of the manner in which Dr. Strong prepared his work on the Calculus. Mr. D. says: "The writer was in almost daily intercourse with him when he was writing his Calculus in Clinton, and was active in inducing him not to fail to do so, and states what he knows to be true when he says that in preparing this great work for publication he brought it forth in its present complete state from the independent action of

his own mind at the time, without the aid of any separate notes or books. It had lain for years in, as it were, chemic solution in his thoughts, and was then precipitated by an act of will into its present form of presentation to others' eyes.

"His memory," says Mr. Dwight, "was not so remarkable as his reasoning faculties. It was never the habit of his mind to undertake to recall its previous mathematical solutions or mental processes. The writer asked him, when he had finished writing out his Calculus, whether, if it should be destroyed, he could write it all over again from memory. He answered, at once, 'No! not at all; but I could write it out anew again from my knowledge of the subject.'"

To this I may add that he was never satisfied to accept at second hand the demonstrations or conclusions of others, however eminent or high as authorities, but always sought to bring out the same result (if true) from some new and self-evident hypothesis, or by some new process of reasoning, generally exhibiting not only striking originality of conception, but a profound knowledge of the entire subject and the principles involved in it.

It is undoubtedly true that in pure mathematical science Professor Strong was a very giant. Other stars of great brilliancy and splendor have since risen in our scientific hemisphere, some of whom have been mentioned in this memoir; but in his day he had hardly a peer in grasp and power of intellect. Between him and Dr. Bowditch there seems to have existed the greatest mutual esteem and regard. If the latter, on account of his age and great attainments, was regarded as *princeps* amongst the mathematicians of this country, to him alone Professor Strong stood *secundus* in the public estimation. Their studies lay in the same direction, and, although the senior of the two was the first to enter the field of transcendental mathematics, yet it is questionable whether Professor Strong was not fully his equal in profound knowledge of the science and the application of its methods to the most difficult problems. His ability was so generally recognized at the period of his settlement in New Jersey that a prominent mathematician of New York, who about that time published a series of difficult problems, which he challenged all the mathematicians in America to solve, expressly excepted Dr. Bowditch, Professor Strong, and one other. But there was no feeling of rivalry between these two great men. Professor Strong always cherished for Dr. Bowditch the deepest reverence

and respect. One of the treasures of his library, most highly prized, was a presentation copy of the translation of The Mécanique Céleste. He had himself studied the original for many years, and had made valuable comments on its most difficult parts; and it must have been to him a source of intense satisfaction to follow Dr. Bowditch over the ground which had been so successfully trodden by both. To these two men, perhaps, more than to any others (unless Dr. Adrian should be added) are we indebted for the introduction of the study of the higher mathematics in this country. It may be added that at Dr. Bowditch's death his family were anxious that Professor Strong should prepare a review of the translation of Laplace, to be inserted in Dr. B.'s biography, and which he expressed a willingness to do; but it seems that the project was, for some reason, never carried out.

Professor Strong, besides being elected an honorary member of the learned societies already mentioned, to wit, The Connecticut Academy of Arts and Sciences, at New Haven, in 1815; The American Academy of Arts and Sciences, at Boston; The American Philosophical Society, at Philadelphia, in 1844, and being appointed one of the original members of The National Academy of Science in 1863, received the honorary degree of doctor of laws from Rutgers College in 1835, and also the same honorary degree from Hamilton College. A much higher testimony to his worth as a man and a professor is found in the universal expressions of esteem and regard with which his name was ever mentioned by those with whom he daily associated, whether professors or students. Hon. A. B. Hasbrouck, who presided over Rutgers College for ten years, from 1840 to 1850, thus speaks of him: "Through the whole course of my office there he was my counsellor and guide, ever ready to advise and assist in all emergencies. It is due to the several classes that passed through the college during my presidency to say that, through his prevailing influence, wisely supplemented by that of our estimable associates, very little embarrassment of discipline occurred—a paternal government met with filial obedience and regard, and scarcely a ripple occurred upon the smooth plane of study and conduct. Professor Strong always carried into his lecture-room the sunshine of his cheerful temperament. Ever ready to applaud a successful recitation he was equally so, by kind and patient assistance, to help the faltering or delinquent in the lesson of the day. No student ever left his room smarting under a

sarcasm or disheartened under a severe rebuke. On the contrary, he habitually planted there, with the seeds of useful knowledge, the germs of affectionate remembrance. In the course of a long life I have met with few men whose characters have exhibited more admirable traits or fewer blemishes to mar their worth. Simple in his manner, courteous in intercourse with all classes of men, tolerant of the opinions of others, but ever ready without offence to uphold his own, honest in the higher sense of moral obligation, constant in his friendships, he held in permanent possession the respect of all who knew him well. Never presuming to scan the mysteries that lie beyond the bounds of human research, he walked humbly in faith, and, after a life of usefulness and virtue, we may believe, according to human judgment, that he will at the great day hear the welcome awarded to a good and faithful servant."

This is but a fair specimen of the testimony to the excellence of Professor Strong's character ever rendered by his associates. The attachment and respect of his pupils here spoken of are not in the least overstated, as is shown by extant testimonials of graduating classes and individuals, and as known and felt by hundreds yet living. Doctor Edward Robinson, the distinguished oriental scholar, who was graduated at Hamilton College, once said that the one man in the world who had most of all roused him to high aims and efforts was Professor Strong. Gerritt Smith, another of his pupils, wrote thus of him in November, 1874: "Hamilton College, my honored mother (especial thanks to Norton and Strong, of blessed memory), taught me a large share of the little that I know, and would have gladly taught me more had I only been more teachable."

Professor Strong was an earnest patriot; a Federalist in his views, as may be supposed from the school in which he was trained; always alive to the political movements of the day; always decided in his convictions with regard to passing measures, topics, and men, and always ready to express his opinions. It was never doubtful where he stood. And it may be added that his country's honor, her greatness and her glory, were ever dear to him.

In person he was a little over the middle height, solidly built, and erect and commanding in figure. He enjoyed a vigorous constitution by nature, and preserved it by temperance and habitual exercise. He had a most benign as well as intellectual expression of countenance, at the same time indicating much positiveness of conviction and general firmness of character. He was, as his nephew

truly describes him, a thorough Christian gentleman. With a manner in social converse decidedly abstract in respect to any formal conventionalities, he was one of the most genial of visitors and talkers. Fond of being questioned on matters of general or special scientific interest and naturally addicted to logical discussion and disputation, he liked particularly to have theological tilts with those who differed from him in their views. He was a habitual reader of the Bible, an observer of the Sabbath, and a regular attendant on public worship. His heart was always full of the moral momentum of the age, and he kept himself at all times well informed, with studious earnestness, of the passing events of the day, nor was he slow to accept the new ideas and efforts which they suggested in respect to the moral, social, or religious progress of the race. He had an abiding sympathy for the oppressed in all parts of the world and a recognition of man as man, aside from all differences of class. He was ever ready to aid the poor and distressed, and some of the most heartfelt grief shown at his grave was manifested by laborers whom he had employed, and who revered him as a sympathizing friend and adviser.

The last years of his life were saddened by the death of his youngest son, Theodore, who died of malarial fever in the army during the late war, in the twenty-fifth year of his age. From this terrible blow he never entirely recovered, and only partially forgot his grief when absorbed in those speculations which had constituted the chief interest of his life. In these, as we have seen, he was engaged to the last, and when the weary frame and over-taxed brain finally gave way it was touching to those who, in his latest moments, watched by his side to witness the efforts of the wandering mind to grasp at the solution of problems which ever seemed to evade him.

Shortly before his death he made a public profession of his religious faith by partaking of the sacraments of the Church. When the pastor and session entered the room he raised his head from his pillow and addressed them as follows: "Gentlemen, I have called you here that I might discharge a most important and too long neglected duty." But he had lived a Christian all his life, had ever borne testimony to his firm belief in all the fundamental truths of religion, and was always decided and outspoken in favor of virtue and in condemnation of vice in all its forms. And, after all, a good life is the best evidence of religious character. If the object of religion is not to make men better, what is it?

Dr. Strong departed this life on the first day of February, 1869, in his seventy-ninth year. To sum up all, we may say, in one word, he was a virtuous, lovable, and manly man; great in his special department, faithful in all his house, and true to the generation in which he lived. It is right that we should honor him in our memories and not neglect to speak his praise.

MEMOIR

OF

DENNIS HART MAHAN

1802-1871.

BY

HENRY L. ABBOT.

READ BEFORE THE NATIONAL ACADEMY, NOV. 7, 1878.

BIOGRAPHICAL MEMOIR OF DENNIS H. MAHAN.

Mr. President and Gentlemen:

At the last stated session of the Academy I was appointed to prepare a record of the life and public services of our late associate, Professor Dennis H. Mahan. It may well be regretted that this duty has not devolved upon one more nearly of his own age, and better qualified, by intimate personal relations, to present a many-sided view of a character which I can only regard with the veneration due from a pupil to an honored instructor. Deeply sensible of individual obligations to him, knowing the wide and lasting influence which he has exerted upon civil engineering and military science in this country, cognizant of the untiring and life-long devotion to duty which was the distinguishing characteristic of his career, I cannot but feel my inability to state in a fitting manner his claims to be regarded as one of our leading pioneers in scientific culture—one who has laid the foundations upon which many have founded titles to lasting fame.

Dennis Hart Mahan was born on April 2, 1802, in the city of New York; but his parents soon changed their residence to Norfolk, Va., where most of his boyhood was passed, deprived by death of a mother's influence, and with no uncommon advantages in the way of early education. He was destined for the profession of medicine, but having a strong taste for drawing, and hearing that this was taught with special care at the Military Academy, he sought and obtained an appointment through the influence of a friend of his family, the Hon. Thomas Newton, then a member of the House of Representatives. His father died shortly after his admission to the institution.

His career at West Point was brilliant. He took and held the first place in a class which at graduation numbered thirty-one members; and included, among others, the distinguished inventor of the Parrott gun. While only a third classman Cadet Mahan received

the unusual honor of an appointment as acting assistant professor of mathematics, the duties of which he discharged, in addition to the full usual course of study, in a manner to win the marked approval of the officers of the institution.

He was graduated in 1824 and promoted into the corps of engineers. After remaining at the academy as an instructor for two years, he was ordered to Europe to study public engineering works and military institutions. By special favor of the French Ministry of War Lieutenant Mahan was allowed to join the Military School of Application for Engineers and Artillerists at Metz, where he remained for more than a year, under the instruction of men whose names were then, and are now, widely known in science. While in Europe he was often an intimate and favored guest of the family of Lafayette.

Returning home in the summer of 1830, he rejoined the academic staff at West Point as acting professor; and on January 1, 1832, formally vacated his commission in the corps of engineers to accept the professorship of civil and military engineering. The duties of this important office he continued to discharge until his death on September 16, 1871—a total period of over forty-one years.

Both Brown and Princeton conferred upon Professor Mahan the degree of A. M. in 1837; and William and Mary, Brown, and Dartmouth added that of LL. D. at a later date. He was elected a member of the Geographical Society of France in 1828, and subsequently became a member of many American scientific associations, being one of the original fifty corporators of the National Academy of Sciences.

Such is the brief record of the professional career of Professor Mahan; but it fails to convey any adequate idea of the influence which he exerted upon engineering science in this country. To appreciate this, it must be remembered that for many of those forty-one years West Point was our only school of mathematical and physical science where the rigid requirements and high standard now deemed essential were even attempted. Every officer of the present corps of engineers who has served long enough to win reputation in the performance of the civil duties assigned to that corps, and many of the eminent civil engineers of the country as well, now gratefully remember how before those old black-boards in that unpretending recitation room at West Point they learned from Professor Mahan, with the rudiments of their profession, a high-toned disci-

pline and the fundamental truth that without precision of ideas, rigid analysis, and hard work there can be no such thing as success.

But if civil engineering owes much to our late colleague, military engineering and the science of war owe more. For many years, and up to the day of his death, he was in that branch of the profession confessedly the highest scholastic authority in America.

By reason of our pacific foreign policy, and of our geographical position which separates us widely from the great battle-fields of civilization, this study receives little attention among us; and for that reason, perhaps, is hardly appreciated even among thoughtful men. Its mental requirements are of a high order. The student of physical science works with definite quantities, and his conclusions are based upon precise premises. In the great game of war the field is more extended, and the skilful player must combine the precision of the mathematician with a profound knowledge of the strength and weakness of human nature. Nothing can be neglected. He must grasp the prosaic but vitally important facts and figures of logistics; the comprehensive theory of grand tactics, by which an unwieldy mass of men can be so directed as to deliver overwhelming blows with the precision of a perfect machine; the resources of the military engineer, by which natural obstacles are overcome and often transformed into advantages; and lastly the great principles of strategy, which, dealing with the hopes, fears, and passions of men, and the moral influence of circumstances upon them—elements more varying than the pulses of the most terrible natural tempest—are yet fixed and immutable as the eternal rock.

To the study and the imparting of this all-important science, upon the proper understanding of which the fate of the nation may at any time depend, Professor Mahan gave the best efforts of his laborious life. It was no perfunctory task. He threw his whole soul into the work; and when his teachings bore glorious fruit upon the fields of Mexico, enthusiasm broke through his habitual reserve; the success of his pupils to him was the vindication of their alma mater against the clamors which had filled the air, and, as one of the officers expressed it to me: "He welcomed me home with moist eyes and a silent grasp of the hand more eloquent than words."

The value of his instructions was again shown upon the more extended theatre of the late civil war. The race was open to many men of character and intelligence, but at the close, with hardly an

exception on either side, those who had studied under Professor Mahan had won the highest laurels.

It would, however, be a great mistake to suppose that the influence of his teachings was exerted only upon the graduates of the Military Academy. In the discharge of his duties he found it necessary to prepare many text-books of instruction, both civil and military. These works have been adopted in other institutions, studied by our citizen soldiery, and to-day they are well known to many who never saw the author.

Briefly recapitulated these works are: His "Treatise on Field Fortification," which first appeared in 1836, has passed through six or seven editions, and is, in the opinion of competent judges, the best work on the subject in the English language. His "Permanent Fortifications," a terse and clear compendium of the principles of the art. His "Advanced Guard, Outpost and Detachment Service of Troops," which first appeared in 1847, but was much enlarged and extended in 1862; together with his work on Field Fortification it was reprinted at the South during the war, and has been largely used in military schools and among the national guard of his native State. His "Treatise on Fortification Drawing and Stereotomy," which was published in 1865. His "Course of Civil Engineering," first published in 1837, and enlarged and reprinted from time to time until 1868. This work is universally known to the profession, over fifteen thousand copies having passed through the press. It has crossed the Atlantic, having been reprinted in quarto form in England, translated in whole or in part into several foreign languages, and adopted in one of the government schools in India. His "Industrial Drawing," first printed in 1855, was specially designed for the use of academies and common schools, into which it has been largely introduced. Finally, his American edition of "Moseley's Mechanical Principles of Engineering," which was published in 1856 and reprinted in 1869, bears many traces of his original mind.

Such was the useful and unselfish life of Professor Mahan, the melancholy close of which it is impossible to contemplate without emotion.

He had become so thoroughly identified in feeling with the Military Academy that every slight cast upon it by hostile tongues was to him a personal insult—every success of one of his pupils a personal gratification. No labor was too severe, no sacrifice was too

great to be made in its behalf. As age advanced, and his health began to suffer, these feelings became morbid; and the idea that his increasing infirmities might, in the judgment of others, render it expedient for him to retire from his laborious post became a nightmare to him. In this state of mind, with which every thoroughly earnest man must feel a profound sympathy, he received a terrible shock when, in 1871, the annual board of visitors recommended his compulsory retirement. Although the President, who well knew his worth, cordially assured him that no action would be taken upon this recommendation, the iron had entered his soul, and he became mentally so depressed that his friends, with reason, grew anxious lest the overtaxed brain might give way under the strain. In his battle of life the time had come when, weakened by disease and suffering keenly under a mistaken sense of non-appreciation, death seemed to his proud spirit the only resource. Had he been confronted with physical foes no one who knew him can doubt that he would have headed a last desperate charge, and, sword in hand, have won a soldier's death; but his foes were mental, and he could only suffer. In the early autumn his mind became unmistakably affected; and, while yielding to the entreaties of his family and friends to visit his physician in New York, the clouds settled thick upon him, and in an instant of acute insanity he plunged from the steamer and ended a life which had become too painful to be longer endured.

Language fails to express the feelings of sympathy, pity, and regret with which the news was received by his pupils in the army. That the aged professor, for whom the respect inspired in the recitation room had long since deepened into admiration and regard as his noble aims and life-long labors were more fully appreciated, should thus pass away, was pathetic in the extreme. A deep sense of personal obligations, and regret that it had not been made more manifest to him, prevailed universally among those who were capable of appreciating the nobility of his character.

Professor Mahan was slight in frame and of an intensely nervous organization. His health was always delicate, and it was only natural ability and indefatigable industry which enabled him to perform so much mental labor.

In his happy home circle he was one of the kindest and most affectionate of men. His attention to the little amenities of life was characteristic, and belonged rather to the old school of polite-

ness than to the less ceremonious manners of the present day. To remain covered when addressing a lady was to him an impossible act even up to the close of his life. His children were taught to observe scrupulous courtesy, and to avoid the use of anything approaching slang language in his presence.

In the section room Professor Mahan usually exhibited the earnest and military rather than the kindly side of his character. All his life a hard student himself, he had no mercy for idleness and but little for stupidity. Anything like a pretense of knowledge or a politic concealment of ignorance was sure to be detected, and in forcing the unhappy offender from his untenable positions the professor often chose stones rather than grass. The first impression which he produced upon a new class was, therefore, often unfavorable, and he was regarded as cynical rather than sympathetic. As the year wore on, however, it always became apparent that his peculiarities were those of manner rather than feeling; and the strong interest which he displayed in imparting knowledge and elaborating obscure and doubtful points produced its effect. His pupils rarely graduated without acquiring a high respect for his devotion to duty, his profound ability, his comprehensive knowledge of the subjects included in his course, and his strict sense of justice.

The young officers of the army who served as instructors under him had, of course, a much better opportunity of understanding his character than the cadets, and they usually acquired for him a warm personal regard. Indeed, it not unfrequently happened that the same individual who as a cadet had considered Professor Mahan to be cold in temperament and cynical in disposition, became as an officer enthusiastic in his praise. He was really a man of warm and kindly feelings and genial humor, and I am told of repeated instances in which he exerted an active influence in behalf of cadets in trouble, entirely without the knowledge of the individual.

As a member of the academic board, of which for many years he was the honored dean, his influence was judicious and conservative. He merged all personal aims in the interests of the Academy, and brought to the performance of his duties the most conscientious impartiality and the strictest fidelity. His pride of character is well illustrated by the fact that, when his own son was passing through the academy, he habitually absented himself from the individual examinations of the boy—in order to avoid the necessity of casting

a vote when his class standing was fixed by the board. It need hardly be added that this class standing, upon which the arm of service and rank as an officer depends, was a matter of great importance, and must have been an object of the deepest solicitude to the father.

Upon the roll of those who have given to the Military Academy the reputation which it bears before the country, the name of Mahan must ever hold an honored place. He has made his mark upon the times in which he lived. His life ended in pain and sorrow, but he now sleeps peacefully under the shadow of those eternal hills among which he labored so long and so faithfully. His memory cannot fail to stimulate in others the growth of those sterling virtues which he so highly prized and so worthily illustrated.

MEMOIR

OF

LOUIS AGASSIZ.

1807-1873.

BY

ARNOLD GUYOT.

READ BEFORE THE NATIONAL ACADEMY, APRIL, 1878.

BIOGRAPHICAL MEMOIR OF LOUIS AGASSIZ.

Mr. President and Gentlemen of the Academy:

For some time past there has been among us a vacant place which cannot easily be filled. The extraordinary personal qualities of character, as well as the talents and attainments of its former occupant, render such a task indeed almost impossible. We, in common with all prominent scientific associations of the country, sorely miss in our meetings the genial countenance, the quick, intellectual eye, the animated words of a colleague who was one of the framers of this Academy, and who never, to his last hour, ceased to be its truest friend and one of the most active contributors. Such indeed was our lamented Louis Agassiz. His untimely death, under the weight of labors disproportionate even to his giant strength, we deeply mourn with all those who have at heart the progress of the science of nature.

Mr. President, you have seen fit to entrust to me the duty of reviewing the life and labors of our departed associate, both for our own benefit and for that of the world at large. While I am deeply sensible of the honor thus conferred on me, I do not less deeply feel the weight of responsibility attached to the office, and almost wish that it had devolved upon one more specifically acquainted with the recent development of zoölogical science. But perhaps your choice was determined by the fact, well known to you, that, owing to circumstances and to intimate relations of friendship, I have been enabled to watch, not only with the deepest interest as a lover of science, but with brotherly fondness, every step of Agassiz in his onward progress from the days of his youth to the time of his death. With these opportunities of obtaining a full insight into his scientific life, and confidently hoping for an ample measure of your indulgence, I felt that it would be ungracious on my part to decline to perform, to the best of my ability, this last duty towards a beloved friend and life-long associate.

Agassiz, in more senses than one, is a unique figure in the history of the scientific progress of our day. In Europe he already occupied among men of science a position in some manner exceptional, I may say privileged, which no other scientific man of equal or even superior merit has enjoyed. In this country, during the last quarter of a century, he has been in the popular mind, more than any other man, the representative of the faithful, unflinching devotee of natural science.

In both hemispheres he found crowds of enthusiastic admirers; in both he became the centre of a marvelous scientific activity, the guide of numerous followers in the investigation of the mysteries of nature. Such facts reveal an individuality of uncommon power which deserves our special attention.

In tracing this rapid sketch it is not my object to intrude upon the sacred domain of private life, into which the public gaze has no right to penetrate; nor will you expect of me so much a rehearsal of the minute circumstances of his life, so often told, as a record of the phases of his scientific career, and such details as throw light upon the character of his native power, the use he made of his opportunities for development, and the glorious results to which he attained.

Near the shore of the quiet Lake of Morat, in Canton de Vaud, Switzerland, on the gentle slope of a lovely hill called the "Vuilly," facing the majestic group of the Bernese Alps, nestles among cultivated fields and vineyards the modest village of Motier. In passing the humble parsonage the traveler's attention is arrested by a tablet of black marble bearing in fresh cut letters this inscription: Louis Agassiz, célèbre Naturaliste, est né dans cette maison, le 28 Mai, 1807. (Louis Agassiz, the celebrated naturalist, was born in this house, May 28, 1807.) This is the simple memorial of the villagers, expressing their pride in the illustrious son of their former pastor.

Here, in the midst of a nature so rich in beauty, the first born son of a charming family, Agassiz passed his infancy and early boyhood with his younger brother and two sisters, under the fostering care of a mother distinguished alike by her intelligence, her wisdom, and the sweet dignity of her manners. His father was a descendant of that sturdy and noble race of French Huguenots, the flower of their nation, driven from their native land by the folly of a demented despot. His mother, Mademoiselle Rose Mayor, was the daughter of a highly esteemed physician of Lausanne. From both,

Agassiz inherited some traits of character, but above all he was a true Swiss, craving free development, undaunted by obstacles, and filled with that instinctive disregard for the shackles of the mere conventionalities of social rank which he retained through life.

Somewhat later his father accepted a call as pastor in the ancient and picturesque city of Orbe, at the foot of the Jura, on the banks of the clear stream of the same name, which, at a short distance higher up, gushes from the bosom of the mountain a ready-made river.

Who can doubt the influence of these magnificent scenes upon the impressible mind of young Agassiz in awakening, developing, and directing his innate love of nature? In both these early places of abode he found, in a rich and varied vegetation, food for his first studies in botany. To the renowned brook trout of the Orbe, and to the fish of the neighboring lakes, objects of his boyish sports, we can trace the early predilection of his observing mind for that class of vertebrates, and the starting point of his classic work on the Salmonidæ, as well as of his extensive studies on the fresh-water fishes, by which he was led to his still more important researches on the fishes of ancient days. In the Jura mountains he found later most of the materials for his great work on the Echinoderms. There also he discovered marks of the presence, in geological times, of gigantic glaciers, descended from the distant Alps.

From his very home he could see looming up before his eyes the snowy heights of the Bernese Oberland; the Jungfrau, with its immaculate white robe; the Schreckhorn and the Finsteraarhorn with their dark, jagged peaks, too steep to retain the snow; both Eigers, with their sharply defined forms, together with scores of other peaks, including Mt. Blanc. Who can count it an accident that these noble heights should afterwards have become the theatre of his celebrated researches on the glaciers? These coincidences show that at this early age Agassiz already possessed that disposition of mind so indispensable to the true naturalist, which leads him to derive his knowledge of nature from nature itself, and not from the observations of others.

The young Louis began a course of classical studies, at the age of eleven, in the College of Bienne, in the neighboring canton of Berne, and was for two years longer a student at the Academy of Lausanne. He then, in 1824, entered upon a course of professional studies in the Medical School of Zurich, where he spent two years.

The sports of his younger days were the collecting, observing, and classifying objects of natural history, to which he devoted every leisure hour. He now began a more methodical study of the science of nature, greatly encouraged by one of his professors, the distinguished zoölogist Schinz. Following the custom of European students, of seeking instruction from the masters in each special department, he left Zurich to pursue his studies in the University of Heidelberg. Here he devoted himself to physiology and anatomy under Tiedeman, the great teacher of the day, to zoölogy under Leuckart, and to botany under Bischoff.

It was in this most charming of German university towns that he found a new friend in a fellow-student whose acquaintance was to mark an important epoch in his life. Alexander Braun, the distinguished botanist and philosopher, the discoverer of the phyllotaxis, who at the time of his death, in March, 1877, occupied the high position of professor in the University of Berlin and the director of its splendid botanical garden, was then also studying in Heidelberg. Similar tastes and an equal enthusiasm for natural science drew these two young men together, and established between them a sympathy which soon ripened into an intimate and lasting friendship. Braun invited Agassiz to spend the long summer vacation of several months with him in Carlsruhe, Grand Duchy of Baden, in company with other friends interested in the same studies.

The terms in which he announced to his family the coming of the new guest is expressive of the fascination which Agassiz's genial nature and early attainments exerted upon all those who met him. "I bring to you," said Braun, in a letter to his father, "one who knows every fish which passes under the bridge, every bird which flies above our heads, every insect which crawls in the grass, every plant which grows on our mountain side," and indeed after his introduction into the family Agassiz seemed to make good the words of his friend.

It was my good fortune to be at this time an inmate of the Braun family, with whom some of my nearest relatives had been on terms of intimate friendship for several years before. I was delighted to hail the coming of my friend and countryman. The arrival of the eldest son of the house, already distinguished by previous scientific publications, with his three university friends, Agassiz, Carl Schimper, the gifted colaborer of Braun in the discovery of the phyllotaxis, and Imhoff, of Bâle, the future author of one of the best en-

tomological faunas of Switzerland and Southern Germany, was a stirring event, which threw new life into the quiet circle. After a short time devoted to a mutual acquaintance every one began to work. The acquisition of knowledge was the rule of the day. Social enjoyment, however great, was but the sweet condiment to more solid food. My remembrances of these few months of alternate work and play, attended by so much real progress, are among the most delightful of my younger days. Allow me to introduce you, for a few moments, into the interior of this gifted and cultivated family, in which the highest aspirations, both to artistic and intellectual excellence, were so happily blended with the good-natured simplicity of manners so characteristic of society in Southern Germany.

Mr. Braun, the head of the family, held the office of postmaster general of the Grand Duchy of Baden, a department which he brought to a high degree of efficiency. He was a man of decided scientific tastes and ability. Mineralogy was his choice, and his collection of minerals ranked among the first in the land.

Mrs. Braun, a woman of uncommon intelligence and literary culture, was the leading spirit of the family, directing into harmonious action all the young and powerful elements under her control. Two sons and two daughters completed the immediate family.

The elder son, Alexander, we already know; the younger, Maxamilian, then a mere boy, inherited the tastes of his father. Later in life he became a skillful mining engineer, and for more than a score of years was chief director of the largest zinc mine of Europe, "La Vieille Montagne," in Morisnet, near Aix-la-Chapelle. Finding himself at the head of 6,000 rough and lawless miners, he attempted a moral reformation imperatively demanded both for the success of his operations and the welfare of the men themselves. In this he was eminently successful, and he had his recompense in the prosperity of that great establishment and in the love and respect of his men. He received from Paris a reward of honor spontaneously granted in acknowledgment of the great services rendered by him in the amelioration of the laboring classes.

The elder daughter, Cecilia, who a few years later became the wife of Agassiz and the mother of all his children, was a noble-minded young woman of rare moral excellence. A dignified serenity, tempered by much gentleness and simplicity of manner, won for her at once respect and affection. Her deeper feelings were

often veiled by a natural reserve, which, however, never assumed the appearance of coldness. Her talent for drawing was of the first order, and she was fond of placing it at the disposal of her favorite brother, Alexander. The drawings of natural objects which she executed for him, and later for Agassiz, commanded the admiration of all by their taste and exquisite correctness.

The younger daughter was already noted for her musical taste and ability, which afterwards developed into a high degree of excellence.

Add to these attractions the charm of the society of a few select and intimate friends, professors, clergymen, and artists, dropping in almost every evening, and you will easily understand how congenial, how fostering to all noble impulses, must have been the atmosphere of this family for the young and happy guests assembled under its hospitable roof.

The very place selected by Mr. Braun for building his residence was expressive of his tastes. It was opposite the large park which nearly surrounds the Grand Ducal Palace, with a view of its beautiful groves, peopled by innumerable nightingales which filled the evening air with their sweet melodies. Behind this curtain of green foliage, almost in sight of the house, was the rich botanical garden with its green-houses, which forms a part of the palace grounds. Within a few steps one of the principal gates of the city opens into a forest of grand old oaks, the Hartwald, which extends nearly to the Rhine. Attached to the Braun mansion, extending into its spacious garden, and secluded from the noise of the street, was a long wing containing a suite of rooms. The chambers in the upper story were destined for the guests; the lower story was devoted to science. The first room below was occupied by the father's rich collection of minerals; the others, full of dried and living plants, growing confervæ, microscopes, and costly books of reference, were the laboratories of his sons and friends. Here were deposited, compared, and submitted to close scrutiny the treasures collected day after day by the little band in the neighboring country. Here, too, were discussed at length with youthful ardor and audacity the theories suggested by the facts observed.

Months were thus spent in constant and immediate intercourse with nature, the subjects of investigation changing with the advancing season. Botany and entomology had first their turn, the collection and study of land and fresh-water shells keeping pace

with them. A delightful excursion to Baden Baden and into the heart of the Black Forest increased still more our stores, but the collection which arises most vividly before my mind is one of mushrooms, gathered in the late fall, chiefly in the forest of Hartwald. Such variety of strange forms, from the clumsiest to the most delicate, now such gorgeous colors, and then again such soft tints; in a word, such a profusion of beauty, unsuspected in this order of organisms, I had never seen before nor have I met with since. The fresh specimens were placed on white paper, the shedding of their spores carefully watched, and their generic and specific characters determined. On rainy days microscopic investigations, especially on the embryogeny of cryptograms, were resorted to, conducted by A. Braun. Practical demonstrations of the phyllotaxis, now gradually reduced to definite formula by Braun and Schimper and shown in various plant forms, but especially in pine cones, were of absorbing interest. The whole plan of the present animal kingdom in its relations to the extinct palæontological forms, was the theme of animated discussions. On the frontispiece of the "Principles of Zoölogy," by Agassiz and Gould, stands a diagram, first suggested by Schimper, at that time, and worked out by Agassiz, which embodies their views and may give a fair sample of the range of questions which already occupied these young brains at the age of twenty years.

It would be idle to attempt to determine the measure of mutual benefit derived by these young students of nature from their meeting under such favorable circumstances. It certainly was very great, and we need no other proof of the strong impulse they all received from it than the new ardor with which each pursued, and subsequently performed, his life-work. Carl Schimper alone, perhaps the most brilliant mind of all, but also the least balanced and the most erratic, was cut off before he could develop all that was in him.

The season of vacation, however, drew to a close. The universities reopened their doors, inviting once more the studious youths to the temple of knowledge. The grateful guests left with regret the happy home which had been theirs for a time, each to return to the university of his choice. I need not say that this first visit of Agassiz to the Braun mansion was not the last. New ties had been formed which drew him almost every year again to the friendly family of which he was to become a member.

Perhaps I ought to ask the indulgence of the Academy for having dwelt so long on these reminiscences of the early—I had almost said of the embryological—period of Agassiz's scientific life. But, if I do not greatly err, Agassiz's later career bears unmistakable marks of the impetus he received at that time from this providential association with equally gifted friends, somewhat older than himself—an association which continued throughout their university life. Mutual influence often opened new avenues of thought and gave a new direction to their investigations. One can hardly fail to perceive that Braun's already advanced studies on the embryogeny of plants suggested to Agassiz a similar series of investigations in the animal kingdom, and prompted, in a measure, that long array of embryological researches of which he was so fond and in which he was so successful.

The bold, but often unsound, generalizations of Carl Schimper, freely discussed in the little circle, drew Agassiz's attention to the principles of zoölogical classification, to which he afterwards devoted so much effort, and to the unity of plan in living and fossil animals, which led him later to those palæontological studies by which he has done so much service to science.

The University of Munich, which had just been reorganized with a galaxy of new professors, all leaders in natural science, medicine, and philosophy, offered attractions which decided the choice of Agassiz, as well as that of his new friend. We find him here with Braun, and somewhat later C. Schimper, from the autumn of 1827 to the summer of 1831, continuing his medical studies, but soon almost entirely absorbed by his zoölogical investigations and the preparation of his first works.

Here he met Döllinger, the founder of modern physiology; Oken, that original genius who inaugurated a classification of the animal kingdom on entirely new principles; Spix, the zoölogist, and Von Martius, the botanist, leaders of the joint Bavarian and Austrian corps of naturalists, recently returned from their scientific exploration of Brazil; Fuchs, the mineralogist; Schelling, the great philosopher, the rival of Hegel and the most illustrious representative of the philosophy of nature. By his enthusiastic devotion to science, and his already remarkable attainments, Agassiz, young as he was, soon gained the privilege of an intimate intercourse with most of them.

He was no less popular with his fellow-students, in whose sports

he heartily joined. At the same time the spirit of the little circle of Carlsruhe continued to live and develop. The three friends had taken lodgings together, and this little band soon became the centre and soul of a society of select young men, who met to discuss scientific subjects and give lectures, each on his favorite topic. The exercises of this debating club were so interesting that it was called "The Little Academy of Sciences," and the professors were often glad to cheer the young students by their presence and to take part in their discussions.

This period of four years was a most important one in Agassiz's scientific life; it was the last formative phase which shaped his subsequent life-work. While he continued with great zeal his original investigations on the fresh-water fishes he sedulously availed himself of the opportunities offered him by his distinguished teachers. With Oken he learned to consider life as a grand unit, and discussed the principles of classification, which occupied in his mind a place of paramount importance. With Döllinger he studied the embryonic development of animals, which remained to the end of his days a prominent subject of his investigations. Von Martius initiated him into the characteristic distribution of plants in tropical climates, especially in that most extensive of all forests in existence, the Selvas of the Amazon. To the influence of Schelling, to whose courses of lectures he listened every year, we may trace, if I judge aright, his deep conviction of the immaterial nature of the life principle, which caused him to consider the diversity of animal forms as the expression of as many thoughts of the Creator.

During these years also he published his first work and began the preparation of two others, which were to establish his reputation as an original investigator. Spix and Von Martius, the two Brazilian travelers, had hardly begun the publication of the results of their journey when Spix, who had charge of the zoölogical portion of the work, was removed by death. Von Martius, who was fully acquainted with the researches of Agassiz on the fresh-water fishes, immediately selected him to fill the vacancy, and entrusted to the youthful student of twenty-one years the description of the fishes collected during the expedition. A large folio volume, splendidly illustrated, published in 1830, was the result; and the manner in which Agassiz performed the difficult task, the original views which he was led, by the recognition of so many new types, to introduce in the classification of fishes, secured for him at once a

place among the best naturalists of the day. He thus obtained a first glimpse of the tenants of the Amazon, that queen of rivers, where it was his good fortune, before the close of his career, himself to make such grand discoveries.

This work completed, Agassiz took up again, with new zeal, his study of the fresh-water fishes of Europe. He devoted his vacations to long journeys, mostly on foot, through Germany and Switzerland, collecting and comparing the fishes of their lakes and rivers, visiting museums, and increasing his stores of natural objects of all kinds.

In thus following the strong bent of his mind, and what he felt to be his calling, Agassiz could hardly give to the professional study of medicine the amount of attention required. His father, becoming anxious about his course, which seemed unnecessarily to prolong his studies and to lead to no regular situation, told him that he would be unable to continue his slender allowance. After the success which attended his first great work, however, his parents felt more reconciled to his plans, and Agassiz, aided by a rich relative, was permitted to go on with his study of natural history. He needed, however, more resources for the preparation and publication of his "Natural History of the Fresh-Water Fishes of Europe." He applied to Cotta, whose name, as a publisher of large and generous views, is known to all the world of science and literature. Cotta, struck with the value of the materials already prepared, and, no doubt, with the genius of the young man, furnished him with means to continue his work and to retain the services of a young artist of talent, named Dinkel, whom he had trained, and whom he afterward employed until he left Europe for America.

Meanwhile Agassiz's attention had been drawn to fossil fishes by the examination of fine specimens from the fresh-water deposits of Glaris in Switzerland, Oeningen in Baden, and Solenhofen in Bavaria. He began to collect all he could obtain, to have drawings made of those which were accessible to him, and resolved to undertake a general work on fossil fishes, which was to become his most important contribution to science.

Before publishing the Brazilian Fishes, in the spring of 1829, he took the degree of Doctor of Philosophy in the University of Erlangen, and a year after passed a brilliant examination for Doctor of Medicine at Munich in April, 1830. His doctrinal dissertation was characteristic of the gallant young man. His theme was, "The

superiority of woman to man," "*Femina humana mari superior*," in which he takes the ground that, according to the law of geological progress, woman having been created last was the most perfect being.

Agassiz now went to Vienna to visit its museums, where he devoted himself especially to the examination of the fishes of the Danube. During his stay in this great scientific metropolis he formed an acquaintance with most of the leading naturalists, particularly with the zoölogist Fitzinger.

Having finished his university studies Agassiz returned to his home in the autumn of 1830, and the question of a situation which would give him a support and the means of continuing his labors pressed itself upon him. The same Providence which had helped him thus far again opened the way for him. His reputation had preceded him in Neuchâtel. One of its wealthy, most influential, and public-spirited citizens, Mr. Louis Coulon, and his son, bearing the same name, both passionately fond of natural history, formed the project of introducing the study of it into the college of their city. To this effect they presented to the institution the large collection which they had accumulated to form the nucleus of a museum of natural history. For the chair which was needed to complete the scheme they looked to their young countryman, already so honorably known. This professorship, however, was not established until the following summer.

Agassiz had now the greatest desire to visit Paris to avail himself of the immense collections of the Museum of the Jardin des Plantes, and especially to examine the fossil fishes it contained, but the means for a protracted sojourn were wanting. Help again came to him from an unexpected quarter. A friend of his father, Mr. Christinat, an humble clergyman, had just inherited a small sum of money and most generously handed it to him for the execution of this cherished project. Agassiz spent a part of the winter of 1831 and all the spring of 1832 in Paris. To make his scanty resources last as long as possible, he took a small and more than modest room in an unattractive street, but which had the merit of being near the Jardin des Plantes, and which on that account had become classic among the naturalists not blessed with an abundance of means. Of the great city he saw nothing; all his days were passed in the museum of that institution. It was here that he became acquainted with Humboldt, who knew him by reputation, and

was so much interested in him and in his researches that he delicately furnished him the means for prolonging his sojourn in Paris, and introduced him to Cuvier, to whom he had dedicated his work on the Brazilian fishes, but whom he only knew by correspondence. Aware that this eminent naturalist was himself gathering materials for a work on fossil fishes, Agassiz had little hope of gaining access to this part of the collections. What was his astonishment and delight when Cuvier, after seeing the extensive preparations Agassiz had made for a similar work, placed at his disposal his entire collection, including even the expensive drawings made from specimens in the British Museum and elsewhere, saying: "You are young and I am old; it is for you now to finish the work which it was my intention to perform and that you have so well begun." This was the bequest of the old master to a young and enthusiastic pupil, full of life and vigor. A few months later, 13th of May, 1832, Cuvier passed away.

Greatly encouraged by these high authorities Agassiz was more eager than ever to establish himself in some position where he could continue this work. Following his own inclination and the advice of Humboldt, he declined the brilliant offers made to him by him by Valenciennes, the colaborer of Cuvier, to become his associate in the continuation of the great "Histoire Naturelle des Poissons," and turned his eyes toward the projected chair in Neuchâtel. Allow me to quote here a part of a letter which Humboldt wrote at that time to Mr. Coulon, to recommend Agassiz for the position. It will show in what high esteem young Agassiz was held by the foremost scientists of the day, Cuvier, Humboldt, and Leopold von Buch:

"This is not so much a favor that I ask of you, sir," writes Humboldt, "as an expression of my sincere gratitude for your noble and generous action toward a young savant, Mr. Agassiz, who, by his talents, the variety and solidity of his attainments, and, what is still more precious, especially in the troubled times in which we live, by his amiability of character, has shown himself so worthy of your encouragement and of the protection of your enlightened government. I have known for years, and especially through our mutual friend, Mr. de Buch, that you have studied natural history with a success equal to your zeal, and that you have made beautiful collections, which are left open and free for the benefit of the public. It is a pleasure for me to see that your good-will is directed towards

a young man, dear to myself, and whom Cuvier, whose loss we shall ever deplore, would have recommended with the same affectionate warmth, founded on the fine work already accomplished. * * * I have strongly advised Mr. Agassiz not to accept the offers made to him at Paris since the death of Mr. Cuvier, and his resolution was formed in advance of my counsels. How fortunate it would be for him, and for the two excellent works in which he is now engaged, if he could this very year be established on the shores of your lake. Great favor will no doubt be accorded him by your worthy governor, General von Pfuhl, to whom I shall repeat my request, as he has honored me, as well as my brother, with a friendship which we highly prize. Mr. Leopold de Buch, almost as much interested as I am myself in the career of Agassiz and in his work on fossil fishes—the most important ever undertaken, and equally correct as to the zoölogical characters and to the formations—has promised me, before leaving Berlin for Bonn and Vienna, to add his entreaty to mine."

The chair was created, Agassiz was appointed, and he returned to Switzerland in the autumn of 1832. His collections were bought for a considerable sum of money, one-third of which was furnished, at the suggestion of Humboldt, by the Prince of Neuchâtel, King Frederick William IV of Prussia, another by the city of Neuchâtel, and the rest by one of its generous citizens, Count Louis de Pourtalès. This enabled Agassiz to begin his projected publications the following year.

These events mark an epoch in the life of Agassiz. The period of preparation is over. At twenty-five years of age a season of intense intellectual activity, rich in fruitful results, now opens before him, embracing all the time of his sojourn in Neuchâtel until his departure for America in 1846. During these fourteen years of incessant labor were achieved, among many others, those of his works which have made the deepest impress upon progressing science—his "*Recherches sur les Poissons Fossiles*" and his "*Système glaciaire.*" He was then in the full vigor of early and mature manhood, when man's intellectual powers are at their height and enable him to open new paths in unexplored regions of the field of Science.

Endowed with an impulsive nature, a vivid imagination, and an inexhaustible buoyancy of spirits, coupled with a consciousness of

exuberant strength, nothing seemed impossible to his scientific ardor.

It was characteristic of him that his plans for any enterprise were always so gigantic as to be out of proportion to the means at his command.

This proved true of the publication of his work on fossil fishes, which he began immediately in 1833, at his own expense. When costly books were to be purchased, artists provided, plates lithographed, help secured, visits to distant museums undertaken, the question of expense was never considered, but rather systematically set aside as an undue interference. "These things are needed for the work" was his uniform answer to friendly remonstrances; to his mind this was enough. Draftsmen of superior talent, trained by himself to the greatest accuracy—Weber, Dinkel, and Sonrel—were constantly in his employ at a regular salary. Dinkel spent seven years in England alone, drawing the fossil fishes placed at Agassiz's disposal by the owners of the richest collections. At the suggestion of Agassiz an extensive lithographic establishment was created in Neuchâtel, which was almost entirely dependent upon him for work. Generous help, it is true, was tendered him from various quarters; by the King of Prussia, at the instance of Humboldt; by the noble friends whom he had gained in several visits to England, Lord Enniskillen, Sir Philip Egerton, Sir Francis Egerton—the last of whom not only allowed him the use of his rich collection of fossil fishes, but bought of him all his drawings, leaving them at his disposal for his publications. Aid also came from the Geological Society of London, as well as from his own relatives; yet it is easy to understand that the weight of an enterprise on such a scale of magnitude was too heavy for him to carry. Still, undaunted by almost inextricable difficulties, he struggled manfully on, during ten long years, till he had completed the work. His "*Recherches sur les Poissons Fossiles*" were published from 1833 to 1843, in five quarto volumes of descriptive text, with an Atlas of nearly four hundred admirably executed plates, and were fitly dedicated to Humboldt.

This work marks a new era in the geological history of the life system. Unlike the mammals described by Cuvier, which appear only at a later period, the Fishes are present through nearly all the geological ages, almost from the beginning of life. Agassiz was thus enabled, by a careful study of this class, to establish on a solid

foundation of facts the precise nature of these laws of gradual progress which give a significance and a peculiar charm to the history of life on our planet.

The sensation produced in the scientific world by this publication was as great as it was universal. It can only be compared to the enthusiasm excited ten years before by Cuvier's "Researches on the fossil bones of the Basin of Paris" and his admirable "Discours sur les Révolutions du Globe," which forms its preface.

Philosophic Germany hailed the new work with delight. Just at the time of the issue of the first volume of the Poissons Fossiles in 1834, when myself a student at the University of Berlin, well do I remember my pleasure in listening to the glowing eulogium bestowed on Agassiz's labors by that deep student of nature and Christian philosopher, Steffens, the colleague and rival in genius of Schelling and Hegel. Agassiz, he said, had demonstrated by facts the very laws he had himself proclaimed from philosophical deductions some twenty years before.

In England and France Agassiz found an equally warm appreciation, and he was soon acknowledged as the first authority in this difficult department of geological science. More than ever museums were open to him. All the fossil fishes of the old red sandstone of England and Scotland which could be obtained, both from public and private collections, were placed at his disposal by the British Association for the Advancement of Science, and their description was published as a monograph, forming a valuable addition to his main work.

It had been his intention to publish a series of similar monographs of the fishes of the various formations in their geographical associations, which would have been of great interest. It is much to be regretted that the multiplicity of new objects which absorbed his attention prevented the execution of this plan.

Before taking leave of these remarkable works, which are the greatest contribution of Agassiz to geology and the most lasting foundation of his well-earned glory, allow me to cast a rapid glance at the most important of the new truths they proclaimed, which were, at that time, a real revelation to science. As most of them have long been a part of the common treasure of knowledge—housholds word of every geologist—we are too apt to forget to whom they are due and the efforts of patience and of genius their discovery required. This review may help us better to realize how

great an advance Palæontology owes to the investigations of Agassiz.

1st. It is well to notice his new classification of fishes founded on more rational principles. By careful researches he had found a remarkable correspondence between the external dermatic covering and the skeleton and internal organization of fishes; he accordingly divided the class into four orders, the Placoids, Ganoids, Ctenoids, and Cycloids, distinguished by striking differences in the structure of their scales.

This view, says Pictet, was the stroke of genius which characterizes the whole work; it was the key to Agassiz's success in classifying the fossil fishes of which often no other parts are found but the scales. The order of their succession in geological times as well as their organization showed the division to be a natural one.

2d. Again, admitting a progressive change from the lower to the higher forms of life, in the successive ages, it was natural to look for the appearance first of the lowest archetypes, the radiates; next the mollusks, articulates, and vertebrates. Agassiz showed that no such linear series exists, but that they appear simultaneously, and not by gradual stages, and, moreover, in great variety of forms and immense number of individuals, a ready-made fauna.

In this primordial fauna Agassiz included the Fishes as representatives of the Vertebrates. This, however, was an error, as has been demonstrated by the fact that the fishes are not only absent from the primordial fauna, but are not found before the very end of the Silurian age.

3d. The earliest forms in each archetype are by no means the lowest in that group, as the Trilobites, for instance, among the articulates, Brachiopods and Cephalopods among the mollusks.

4th. The Vertebrates alone begin the true historic series, terminating with Man. The successive appearance of their classes marks the great steps in the path of progress, the ages in the life system, while the Invertebrates play, in this respect, altogether a secondary part.

5th. Each class, each group, has a history peculiar to itself. Among the Invertebrates, for example, the Cephalopods of the primordial fauna grow more diversified in the Devonian, culminate, both in number of species and beauty of forms, in the Mesozoic, then rapidly decrease, and are scarcely seen at the present time. Among the fishes the Ganoids and Placoids appear at once in great

diversity. They have their predominance in the Palæozoic time and linger through the periods anterior to the Cretaceous formations, but their most typical families die out before the present era, in which only a few specimens are left. In the Cretaceous the Ctenoids and Cycloids make their appearance, as diversified in their origin as the two orders preceding them, and culminate at the present time.

6th. The early types of a class present characters analogous to those of the embryo of an individual of the highest type of the class, and the following ones, in the geological succession, are analogous to the forms through which the same individual embryo passes during the phases of its development: The Trilobite, of Palæozoic times, typifies the form of the embryo of the crab; the Macrourans, of the Mesozoic, the middle stage; the more recent Brachyurans, the last form of the full-grown crab. The succession of forms is the same in the development of the class as in the phases of growth of the individual crab. In fishes the inequality of the lobes of the tail (heterocercal), so characteristic of the palæozoic types, is found in the embryo of many of the Ctenoids and Cycloids, while the lobes become symmetrical in the full-grown animal.

7th. Applying the results of these admirable researches to the geological history of the whole life system he lays down the important general law "that the successive creations have undergone phases of development analogous to those observed in the gradual growth of the embryo, and similar to the gradations which characterize the ascending series of the present animal creation in its totality."

8th. This community of laws which binds the living beings of the past ages by indissoluble ties to those of the present time shows that they form together one grand *Life System*, in which the fossils supply the links needed to fill up the numerous gaps found in the series of animal forms now in existence. (Poissons Fossiles, page 168.) "I do not doubt," he adds, "that we shall soon be brought to combine, in a single view, the results of palæontological and zoölogical researches, including comparative anatomy, as soon as we shall attempt to establish a complete system of the natural affinities in the totality of the animal kingdom, and that we shall have to give more and more weight to the order of the geological succession of the types in their systematic arrangement."

9th. In view of the fact that all the fundamental types appear

simultaneously at the beginning of life, and that the mode of their subsequent development takes place by sudden steps, Agassiz declares his conviction "that these types do not descend from one another by direct procreation, or by successive transformation, but that they are materially independent, though forming an integral part of a grand systematic whole, whose connection is to be sought in the creative intelligence of its author." (Vol. 1st, page 170.)

10th. Summing up these results and rising to still higher considerations he expresses, in the last page, the views of the order of creation suggested by his studies. "Such facts," he writes, "loudly proclaim principles which science has not yet discussed, but which palæontological researches place before the eyes of the observer with increasing persistency: I mean the relation of the creation to the Creator. * * If I have refrained from expressing my conviction on this subject till the last moment it is not because I shrank from the discussions, sure to arise on the announcement of these results, but because I did not wish to call them out before being able to place them on purely scientific ground and to sustain them by satisfactory demonstrations rather than by a profession of faith. More than 1,500 species of fossil fishes with which I havebecome acquainted say to me that the species do not pass gradually from one to the other, but appear and disappear suddenly without direct relations with their predecessors; for I do not think that it can be seriously maintained that the numerous types of Cycloids and Ctenoids, which are nearly all contemporaneous with each other, descend from the Placoids and Ganoids. It would be as well to affirm that the mammals, and man with them, descend directly from fishes. All these species have a fixed time for coming and going; their existence is even limited to a determined period. And still they present, as a whole, numerous and more or less close affinities, a determined coördination in a system of organization which has an intimate relation with the mode of existence of each type, and even of each species. More still, there is an invisible thread which is unwinding itself, through all the ages, in this immense diversity, and offers as a final result a continuous progress in this development of which man is the termination, of which the four classes of vertebrates are the intermediate steps, and the invertebrates the constant accessory. Are not these facts manifestations of a thought as rich as it is powerful, acts of an intelligence as sublime as provident?

* * * This is, at least, what my feeble intellect reads in the works of creation."

Whatever be the opinions which many may entertain as to the interpretation of some of these generalizations, the vast importance of these results of Agassiz's studies may be appreciated by the incontestible fact that nearly all the questions which modern palæontology has treated are here raised and in a great measure solved. They already form a code of general laws which has become a foundation for the geological history of the life system, and which the subsequent investigations of science have only modified and extended, but not destroyed. Nowhere did the mind of Agassiz show more more power of generalization, more vigor, or more originality. The discovery of these great truths is truly his work; he derived them immediately from nature by his own observations. Hence it is that all his later zoölogical investigations tend to a common aim, viz., to give by further studies, equally conscientious but more extensive, a broader and more solid basis to these laws, which he had read in nature and which he had proclaimed, at that early date, in his immortal work. Let us not be astonished that he should have remained faithful to these views to the end of his life. It is because he had *seen* that he *believed*, and such a faith is not easily shaken by new hypotheses.

Agassiz had thus nobly accomplished the task entrusted to him by the founder of palæontology. He had completed, by his "Recherches sur les Poissons Fossiles," the work begun by the great author of the "Recherches sur les Ossements Fossiles du Bassin de Paris."

While this central work was progressing the activity of his mind allowed him to carry on simultaneously a multitude of other investigations and publications. Under his magnetic influence Neuchâtel soon became a centre of scientific activity such as it never was before nor has been since. The City Museum of Natural History, begun by the rich collections of Coulon and Agassiz and under their fostering care, was gradually increased by the contributions of other friends, and grew into a model of taste and arrangement. Many rich citizens united to send, in 1839, an already distinguished Swiss naturalist, Von Tchudy, partly a pupil of Agassiz, to South America as collector for the museum, and the scientific world owes the remarkable books on the Andes, published by this gifted traveler, to the investigations which began with that expedition. A

society of natural sciences, of which Agassiz was the first secretary, was started in December, 1832, and the bulletin of its proceedings, as well as the series of its quarto memoirs, richly illustrated with plates and maps, give evidence to this day of its vitality.

The impulse imparted by Agassiz soon showed itself by deeds. To members of this society were due some of the chief contributions on the geology of the Jura. A. de Montmollin recognized the Neocomian, until then regarded as belonging to the Jurassic layers, as a distinct formation, constituting the lowest members of the Cretaceous series, since identified everywhere and admitted as one of its normal formations. Gressly, one of the pupils of Agassiz, well known by his important publications on the geology of the Jura; Nicolet, who gave a valuable description of the valley of La Chaux de Fonds, which has become typical of the Jurassic valleys—all partook of Agassiz's enthusiasm for scientific researches. The publication of the quarto memoirs of the Helvetic Society of Natural Sciences, with their numerous plates, was transferred to Neuchâtel under the superintendence of Agassiz.

Meanwhile he was continuing his investigations on the fresh-water fishes. In 1834 he published a description of new species of *Cyprinus* from the lake of Neuchâtel (Mem. Soc. and Sc. Nat. Sc., Neuch., vol. I). In his study was made the first and entirely successful attempt at an artificial fecundation of fishes, an art which has since become, as the academy is well aware, of such vast economic importance. An atlas of exquisite plates, destined for his projected "History of the Fresh-Water Fishes, but comprising only the family of *Salmones*, was executed, under his immediate supervision, by his skillful lithographer, Nicolet. We truly wonder at their beauty, and at their perfection of color and outline, when we remember that they were almost the first essays of the newly-invented art of chromolithography, and produced at a time when France and Belgium were showering rewards on very inferior work of this kind as the foremost speciments of progress in that art. The expense of the work executed on this scale of excellence became altogether too great and it had to be discontinued. Agassiz, however, in 1839, associated with him in his work Carl Vogt, a young physiologist, pupil of Prof. Valentin, in Bern, who carried on, under Agassiz's direction, a series of researches on the anatomy and physiology of the Salmones, which were embodied in a volume published in 1844. In the preface Agassiz informs us that the Osteology and

Neurology are due to him; the remainder and the drawings to Carl Vogt.

While studying so closely the fishes Agassiz did not neglect the other classes of animals. The Invertebrates received a large share of his attention.

In 1834 he published, as a preparatory work, a Prodromus of the Echinoderms, which was followed in 1839 and 1840 by a description of the fossil Echinoderms of Switzerland, and also by several monographs from 1841 to 1842, for which he associated with himself Desor for the descriptive part and Valentin for the anatomy of the genus Echinus. Another large quarto volume, with nearly 100 plates, was published in 1840 to 1845 under the title of "Etudes critiques sur les mollusques fossiles," the main object of which was to discuss anew the identity of fossil species of different geological formations, the relations to the living ones, and the question of their classification. Another illustrated memoir, "Iconography of the tertiary shells believed to be identical with the living ones," was issued in 1845.

The prominent feature of these various works was that they were all undertaken not simply to increase the number of described species, but with the view of elucidating some principle deemed important by their author.

This is perhaps the place to notice a faculty of Agassiz, which was one of the secrets of his success as a naturalist. He was endowed with a most exquisite sense of form. At a glance he perceived, as by intuition, the characteristic form of an animal as well as its minute details. This once vividly impressed on his plastic imagination would never be forgotten. It was astonishing to see how, in passing his eye over a large collection, he would at once detect the new forms which he had not seen before and add them to his treasure of mental photographs.

Though, according to his own statement, he had no talent for drawing on paper, when in the heat of an exposition before the black-board, his hand would reproduce, almost instinctively, the vivid image which he had in his mind in singularly correct outlines. If Agassiz has sometimes been charged with increasing unnecessarily the number of species, it is no doubt owing to that strong discriminative power which allowed him to see differences unperceived by others. These minute researches, however, had an excellent influence in introducing a greater precision in palæontological determi-

nations. We may ascribe to the same cause the fact of his finding reasons to deny the identity of almost every species belonging to different geological ages, and even of any tertiary species with those of modern times.

Hence, also, he never planned and published a work without an abundance of illustrations. By his advice Gressly constructed relief maps of the Jura to illustrate its geology. Another, on a large scale, of the Canton of Neuchâtel is still preserved in the museum of that city.

In order to multiply the types referred to in the above-mentioned works, and thus facilitate his studies, he had some 500 specimens of his collection reproduced in plaster casts—a method on which he wrote a special memoir and which has since been in universal use.

Two other works, only instrumental for researches, but implying a vast amount of labor, were prepared. The "Nomenclator Zoölogicus," in 1841, contained an enumeration of all the *genera* of the animal kingdom, with the etymology of their names, the names of those who first proposed them, and the date of their publication, the nomenclature of each class having been submitted to the revision of naturalists, masters each in their respective branch. Another extensive publication, the "Bibliotheca Zoölogica and Geologica," in some measure a complement to the first and containing a list of all the authors named in it, with notices of their works, appeared under the auspices of the Royal Society of England, and was issued, with emendations and additions by H. Strickland and Sir W. Jardine, in four octavo volumes, after Agassiz's departure from Switzerland.

Well-nigh overwhelmed by all these enterprises carried on together, and every day increasing, Agassiz, who was as little inclined to write as he was indefatigable in investigating, felt the necessity of help in this direction. In 1837 he found in the ready and elegant pen of Edward Desor, a former student of law, the aid he needed. He engaged him as a secretary—with his usual kind-heartedness received him in his family and made him his associate in all his studies. Though entirely unprepared by his previous training Desor, endowed with a quick mind, fulfilled his new functions with great success, and under the direction of his employer became, in a measure, his colaborer in the field of science, especially for the descriptive part. He was Agassiz's constant companion in his expeditions on the glaciers, and took a prominent part in the

final elaboration of the results of their studies, as well as in the publication of his works on the Echinoderms, and after their separation continued an independent and honorable career in the field of science.

In casting a glance at these varied labors we cannot but admire the extraordinary industry displayed by Agassiz in this remarkable decade of his life, and also his marvelous power in inciting, directing, and organizing the work of the numerous helpers whom he knew how to employ. All those engaged with him caught a sparkle of his ardor and worked with a will—all drew a direct benefit from their intercourse with him. The artists felt their powers raised to a higher degree of perfection by his demands on their talent; the others learned how to see and observe, and every day became conscious of new progress in the path of knowledge.

But this was not all. In the midst of these zoölogical labors an event occurred which, for a time, diverted the mind and powers of Agassiz into an apparently entirely new channel. In the summer of 1836 he paid a visit to his venerable friend, Jean de Charpentier, director of the mines of the Canton de Vaud. This veteran geologist, two years before, in a communication to the Helvetic Society of Natural Sciences, had attributed the transportation of erratic boulders to the agency of enormous glaciers of ancient times. Agassiz, desirous to examine the facts upon which so startling a statement was based, spent five months with him at his charming residence in Bex, not far from the entrance of the Rhône into the lake of Geneva. Here, surrounded by erratic boulders of all sizes; almost in sight of the classic group of the gigantic blocks of Monthey, descended from Mt. Blanc; near the glacier of the Diablerets, where the moraines, the polished and grooved surfaces, the *roches moutonnées*, could be observed; where the transportation of the boulders lower down could be followed; and with such a guide and expounder of the glacial phenomena as Charpentier he had every opportunity he could desire for his purpose. He came home full of enthusiasm and thoroughly convinced of the reality of the facts he had seen and of the soundness of the conclusions of Charpentier. The presence of Alpine boulders on the slopes of the Jura had been attributed from the time of de Saussure and de Buch to immense torrents descended from the Alps. Agassiz found there, the same year, the polished and smooth surfaces which to every practiced observer gives unmistakable proof of the former existence of a gla-

zier. For the first time he realized the astounding and apparently incredible fact that the vast plain of Switzerland between the Alps and the Jura, now covered with cities and cultivated fields, was, in days long gone by, overlaid by a sheet of ice 2,400 feet in thickness. He did not stop there. With characteristic boldness he applied to the whole globe a state of things which he had found true on this one particular spot. He conceived the idea of a universal glacial era extinguishing all life at the end of the tertiary age and separating it from the present geological epoch—the historical age of man. The following summer, in 1837, he embodied his new ideas in an inaugural address delivered as president, for the year, of the Helvetic Society of Natural Science, in session at Neuchâtel.

This bold theory, so strange, apparently so improbable, so contrary to all accepted notions, took every one by surprise. Coming as it did from a recognized and favorite leader in science it could not help making a great sensation. By some it was received with open contradiction, by a few as deserving attention, by the venerable Leopold de Buch, the old patron of erratic boulders, with wrath and scorn; by most with a smile of incredulity. This communication, no doubt, contained some very crude notions which had to be abandoned—many assertions unsupported by the facts known at the time; but the grand idea of a universal glacial era, as one of the geological phases of the earth—that happy guess, as one might call it—was started and was destined to make its way in spite of all contradictions. Now, thanks to the growing number of well-established facts which lead to this conclusion, the evidence of its reality is so overwhelming that it is accepted by all, though in a modified and limited form, as a geological truth no longer to be controverted.

From this time on the glacial question occupied a large share of Agassiz's time and attention. His enthusiasm on this theme was unbounded. Almost every summer, from 1837 to the time of his departure from Switzerland, was employed in investigations among the glaciers of the Alps.

To give to the theory the necessary base of facts two orders of observations were indispensable—one purely physical, the glacier and its phenomena; the conditions of its formation and growth, the law of its motion, its moraines, its action on the ground over which it moves; the other geological, the erratic phenomena, the law of the distribution of the Alpine boulders and fragments, and of their

extension, both horizontal and vertical. As the history of these researches requires a brief mention of the part taken in them by myself I beg leave of the Academy to say a few words on this subject.

In the spring of 1838 I had the pleasure of a visit from my dear friend Agassiz in Paris, where I then resided. The main topic of conversation was, of course, the glaciers. He put me au courant of Charpentier's views, as yet imperfectly published (his book having been issued only two years later, 1840), and, adding his own idea of a general glacial era, he urged me to turn my attention to these phenomena. I asked to be allowed to suspend my judgment until my own observations should justify my adhesion to so startling a theory, but promised to visit the glaciers that very summer. I did so, and an exploring tour of six weeks in the Central Alps rewarded me beyond my expectation. The glacier of the Aar, on which Agassiz began two years later (1840) his regular system of observations, taught me the law of the moraines. The glacier of the Rhône gave me the law of the more rapid advance of the centre of the glacier and that of the formation of the crevasses, both transversal and longitudinal. The glacier of Gries showed me the laminated or ribboned (blue bands) structure of the ice deep down in the mass of the glacier and the law of the more rapid advance of the top over the bottom. On the southern slope of Mont Blanc, the great glacier of la Brenva, with its twin rocks, rising like two dark eyes from the middle of the ice (they are indeed called by the mountaineers the "eyes of the glacier") made me understand that the motion of the glacier takes place by a gradual displacement of its molecules under the influence of gravity, giving it a sort of plasticity, and not by a simultaneous gliding of its whole mass, as believed by de Saussure. All these laws, deducted from a first but attentive study of the phenomena of the glaciers, were at that time, excepting that of the moraines, new for science. They were expounded by me and illustrated by diagrams at the meeting of the Geological Society of France in session at Porrentruy the same summer of 1838, and I had the great satisfaction of seeing them fully confirmed by the subsequent observations of Agassiz and others, which furnished the precise numerical data then wanting for their complete elucidation. This paper, however, though duly mentioned in the proceedings of the Geological Society (Bulletin, Vol. IX, page 407), was not printed, owing to a protracted illness

of its author in the winter following. But on the occasion of a claim by Prof. J. D. Forbes to the discovery of the laminated or ribboned structure of the ice the portion relative to this subject was printed, and the whole manuscript, on a motion of Agassiz, was deposited, by a formal vote, as a voucher in the archives of the Society of Natural Sciences of Neuchâtel, the original draft being now in my hands.

If I mention this circumstance it is because the regretable omission of the publication of my paper was the occasion of the unfortunate misunderstanding which estranged two such men as Agassiz and Forbes, and which I feel bound in a measure to explain.

Two years later, in 1840, Agassiz invited Forbes, whose attention had just been turned to the study of the glaciers, to be his guest on the glacier of the Aar, where he had just established himself with his assistants for a protracted season of observations, offering to make him acquainted with the results thus far obtained by his own exertions. Forbes accepted. In one of their common excursions the peculiar laminated structure of the ice was noticed. Forbes, who had never heard of it, believed he had made the discovery of a new and important fact. Agassiz, who two years before had been present at the meeting at Porrentruy and had heard the paper read by me in the Geological Society of France, remembered the description of the phenomenon, probably well nigh forgotten amid the crowd of other apparently more important questions which were agitated at that stage of the study of the glaciers, and he maintained its earlier discovery. Such an occurrence was so natural in these circumstances that we wonder, not that it should have happened, but rather that it could have become the cause of so much trouble.

The foundation of the Academy of Neuchâtel, in 1839, with the object of furnishing a University course of studies to the post-graduates of the College, brought me back to my native town. Having accepted a call to one of its twelve professorships, I became the colleague of Agassiz. The investigation of the glacial phenomena could now be pursued with more advantage by dividing our forces. Agassiz having chosen to continue his studies on the glaciers, which had already engaged so much of his attention, I left this field and took charge of the intricate question of the erratic boulders, the glacial drift, and the ancient extension of the glaciers. To the elucidation of this geological part of the question I devoted, absolutely

single handed, seven laborious summers, from 1840 to 1847, only giving myself, at the end of my working season, the pleasure of a visit of a few days to the lively band of friends established on the glacier of the Aar, in order to learn the results of their doings and to communicate mine to them.

The first serious studies of Agassiz and his companions were made on the grand group of glaciers descending from the snowy crests of Monte Rosa, and of which the glacier of Gorner forms the centre. The result was a first publication, "Etudes sur les glaciers," in 1840, accompanied by a superb atlas of thirty-two plates, which makes its greatest value, and has furnished most of the illustrations which we find to this day in our scientific text-books.

In 1840, however, he finally selected, as most appropriate to his purpose from its easy access and vast extent, the glacier of the Aar, in the very heart of the Bernese Oberland, and at the foot of its highest peak, the Finsteraarhorn. Here, on the medial moraine, in the very midst of the glacier, not far from the confluence of its two main branches, the Ober Aar and the Lauter Aar glaciers, stood a large boulder conveyed by its slow motion from the foot of the mountain. This was selected as the abode of the little band. Under one of its projecting corners six men found room to repose on its icy floor. A blanket suspended in front protected them from the frosty air of the night; another served as a common covering for the whole company; a block of ice outside, crowned by a flat stone, made their kitchen, presided over by a practiced guide. This was the "Hôtel des Neuchâtelois," which soon became celebrated throughout Europe. Later, when yielding to repeated frosts, the boulder crumbled to pieces, it was replaced by a large tent scarcely more comfortable.

Instruments were procured, and boring apparatus destined to send self-registering thermometers to the depths of the glacier to ascertain its temperature. The position of eighteen of the most prominent blocks on the glacier was determined by careful triangulation by a skillful engineer, and measured year after year to establish the rate of motion in every part. The difference in the rate of motion in the upper and lower part of the glacier, as well as at different seasons of the year, was ascertained; the amount of annual melting was computed and the phenomena connected with it studied. The surrounding peaks, the Jungfrau, the Schreckhorn, the Finsteraarhorn, most of them until then reputed unscalable, were ascended

and the limit of glacial action discovered; in short, all the physical laws of the glaciers were brought to light.

Meanwhile the geological question of the erratic boulders and deposits, which I had undertaken, was gradually being solved. The existing documents on the erratic deposits of the Central Alps were then very few. The older observations of de Saussure, de Buch, and Deluc, on the Alpine drift of the Swiss plain and on the erratic boulders of the Jura, and a few of Escher de la Linth in the eastern part of Switzerland, were entirely inadequate to the purpose. The classical work of Charpentier on the erratic deposits of the Rhône Basin had not yet been published. The various erratic regions had to be determined by their characteristic rocks; their true limits, as yet entirely unknown, had to be fixed and their lines of contact sharply defined; their boulders traced step by step from the top of the Jura across the plains and Alpine valleys to their parent rocks, in the heart of the snowy Alps; the height of their limit along the mountain slopes measured; the glacial marks and polished and scratched rocks carefully noted. This was done. Thus eight erratic basins were recognized on the northern slope of the Alps: those of the Isère, the Arve, Rhône, Aar, Reuss, Limmat, Sentis, and Rhine, and four on the southern slope, the Adda and Lago di Como, Lugano, Ticino and Lago Maggiore, and Val d'Aosta.

Moreover, a question left hitherto untouched, the distribution in each basin of the rocks special to it, was minutely examined and the final results of all the laws observed in the arrangement of the erratic fragments were shown to be identical with the laws of the moraines.

This identity and the absolute continuity of the erratic phenomena, from the heart of the Alps down the slopes of the valleys and beyond to the Jura, left no alternative but to admit the ancient existence of mighty glaciers, as vast as the erratic regions themselves, meeting in the plain of Switzerland, stemmed by the wall of the Jura and having a thickness of over 2,000 feet.

It was the intention of Agassiz to embody the results of these combined studies in a publication, "The Système Glaciaire, by Agassiz, Guyot, and Desor," in 3 vols., the 1st to contain the Glaciers, by Agassiz; the 2d, the Alpine erratics, by myself; the 3d, the erratic phenomena outside of Switzerland, in Europe and America, by E. Desor. The 1st vol. alone was published in Paris, in 1847, under the the title of "Nouvelles Recherches sur les

Glaciers." The Revolution of 1848 and its consequences put an end to this project. The 5,000 specimens of erratic rocks of Switzerland, the vouchers for the results obtained, and only partially published, are now in this country. This unique collection is exhibited, with explanatory maps, in a special room of the Geological Museum of Princeton College.

Here end the contributions of Agassiz to the science of the glaciers. Many of his conclusions may be contested, but the main laws of their mechanism were established. Little remained but the more delicate questions whose solution required the science of special physicists.

If to Venetz and Charpentier belongs the honor of having first proved the transportation of the Swiss erratic boulders by the agency of ice, and the existence of great glaciers formerly extending to the Jura, to Agassiz we must award the merit of having given to these facts their full geological significance, of having brought them before the world at large and having made the glacial question, as it were, the order of the day. By his sacacity he found glacial action where it was never suspected before; pointed it out to the astonished and unbelieving English geologists on their own soil; found it in North America, traced it with undoubted evidence in the temperate regions of South America, and believed, though hardly with sufficient reason, that he had seen it on the vast plains of the Amazon. He proved the phenomenon to be well nigh universal.

This period, it must be owned, was but an episode in Agassiz's scientific career, but it was a brilliant one, which carried his name far beyond the limits of the scientific world.

But with the vast number of expensive publications and the expeditions to the glaciers, which cost him sometimes in a single summer nearly his salary for the whole year, it is not astonishing that he incurred pecuniary responsibilities which required years of labor in after life to discharge. Providence again opened the way to bring him out of these increasing difficulties. His old and generous friend, Humboldt, was again the instrument. For a long time he had mourned the direction which Agassiz's studies had taken. He believed him out of his track in devoting so much time and thought to the glaciers, and many of Agassiz's best friends shared in this opinion. Humboldt obtained for him from the King of Prussia a scientific mission the object of which was to compare the faunas of

the temperate regions in Europe and America. A sum was placed at his disposal for this purpose, while his salary was continued. He received at the same time an invitation from John A. Lowell, Esq., to lecture before the Lowell Institute in Boston. He spent the winter of 1845-46 in Paris, completing his researches on the Echinoderms by the aid of the immense collections always freely open to him.

After a short sojourn in England he sailed for Boston in September, 1846.

The scene of his labors is now transferred to the New World, and a new period of his life begins.

The same popularity and success which had always attended him in his own country followed him across the Atlantic, and new friends were ever ready to rally around him. His lectures in Boston and the principal cities of the United States excited the liveliest interest. In this new period, while prosecuting his investigations with redoubled zeal, on a wider field, admirably suited to the breadth of his mental grasp, Agassiz stands out before us prominently as the great teacher of natural science—a teacher not only of the few in the seats of learning, but of the nation at large. Before him America had had many able representatives of the science of nature, fully appreciated abroad, but too much ignored by the mass of the people at home, who had not yet espoused the cause. Sympathy and efficient aid had been wanting. The stirring appeals of Agassiz were heard and the nation nobly responded.

The founder of this academy, the enlightened and far-seeing head of the Coast Survey, Dr. A. D. Bache, furnished him the much-coveted opportunities for extending his researches among the marine animals on the Atlantic coast and Florida. The Thayer expedition to Brazil and the Amazon, the generous subscriptions for the publication of his "Contributions to the Natural History of the United States," the Anderson school at Penikese, are palpable evidences of the universal readiness to foster his cherished projects. The Scientific School of Cambridge, founded in 1847, the Agassiz Museum of Comparative Anatomy and Zoölogy, in 1857, and the universal interest in science now awakened are lasting monuments of his beneficent influence.

I am sure it is not in this Academy that we shall hear a dissenting voice as to the immense power he has exerted in this country in spreading the taste for natural science and elevating its standard.

How many leading students of nature are proud to call themselves his pupils and gratefully acknowledged their great indebtedness to his judicious training. How many who now occupy scientific chairs in our public institutions multiply his influence by inculcating his methods, thus rendering future success sure.

Public education had no better friend. He published an excellent little volume on the method of study in natural history. He was one of the corps of able teachers gathered together by the genial and intelligent State Secretary of Education of Massachusetts, Dr. Barnas Sears, which, by means of the Teachers' Institutes, actually revolutionized the methods of instruction. It was to me supremely touching to see the great naturalist, at Penikese, a few months before his death, devoting his last strength to a crowd of eager learners, directing them to the exclusive study of the book of nature, and showing them, by word and deed, how to observe it and how to be taught by these living realities.

Of his numerous labors since he landed on the American shores I will only mention his researches in the various families of Radiates; on the Florida reefs in behalf of the Coast Survey; his great work, "The Contributions to the Natural History of the United States," three volumes of which have been published, prefaced by a suggestive essay on Classification; the exhaustive embryology of the Turtle; his volume on the Expedition to Lake Superior; his "Journey to Brazil;" the Hassler expedition round Cape Horn, and so many others, to give even a short notice of which would carry me too far. I will only say that they all exhibit that superior talent of observation, true to the most minute details, while they show the same regard to the bearing which this new information might have on the higher principles of science, the same care to connect the observed phenomena in a code of doctrine. All the ideas brought out in his "Poissons Fossiles" reappear, but more matured and placed on a broader foundation. This is especially true of his remarkable essay on Classification.

It is on the broad principles laid down in this last work that the organization of the Cambridge Museum of Comparative Zoölogy is based. This latest enterprise, and surely the most enduring monument of Agassiz's scientific activity in America, is not an ordinary conception. Its triple series, *Zoölogical*, designed to illustrate the systematic affinities of the animals among themselves; the *Geographical*, showing their natural associations in the regions where they

live, including the *fossil types* to mark their successive appearance in geological times and their relation to the present creation; lastly, the *Embryological* series, unfolding the various grades of development, and enabling the student to compare them with the fossil types of early times; these three form a complete system demonstrating all the relations of the animal kingdom considered in itself and in connection with the surrounding world, past and present. It is a stereotyped form, a realization of his original ideas, developed throughout his life. No wonder that he devoted to this monumental work all his remaining strength to the very end of his days.

Permit me here to allude to one of the providential circumstances of Agassiz's life, which enabled him to perform so large an amount of work, and to do it cheerfully as well as efficiently. I mean his marriage, in 1849, with a distinguished daughter* of his adopted country, whom we all know without naming her, and all admire and respect. In this constant and devoted companion of his American life he found a wise and affectionate mother for his children. Her sound and firm judgment, her well-balanced mind, gave him a much-needed help and encouragement in the midst of sometimes complicated circumstances. Her literary talents, to which we owe the interesting record of his Brazilian journey, the picturesque account of the Florida reefs, and perhaps the final appearance of more than one of his late works, are acknowledged by all. Her deep and absolute devotion, her soothing influence, secured for him the peace of mind and heart so necessary for an undisturbed mental activity. To her also Science owes a tribute of gratitude.

Agassiz was born a naturalist as Raphael was born a painter. Nature was his first and last love; to live with her and study her was his life. His allegiance to her was unreserved. To be false to nature, or to belittle her—to warp her teachings, or to set them aside—was an offense which he resented almost as a personal one to himself. One of his last sayings (in the Atlantic Monthly) was that "philosophers and theologians have still to learn that a physical fact is as sacred as a moral principle."

Nature was his main teacher. From her he knew God as a personal mind; all wise, all powerful. Each specific form of plant or animal was to him a thought of God. The life system was God's

* Miss Elizabeth Cary, of Boston, Mass.

connected system of thought, realized by His power in time and space. These forms were not the result of blind physical forces. To these he conceded no power to produce any change in their permanent specific types. New species were new creations. Hence his constant and resolute opposition to Darwinism and to all evolution hypotheses. This zoölogical view he applied equally to mankind. Though a believer in the psychological unity of mankind, he maintained the doctrine of an original variety in the different types of man.

Such were his intellectual views of nature, but his heart taught him more. I remember the tear of emotion which glistened in his eye when he spoke with thankfulness of the gifts of a kind Providence to himself and the perfect happiness he had in every member of his family. If his mind recognized God's wisdom in nature, his heart surely felt that in God there is more than mind; there is tender love.

By his large contributions to Science in America, by his power of developing a true scientific spirit, to excite and popularize the taste for scientific researches, by his vast influence on the American mind, and his universal popularity, which he kept to the very last, Agassiz had become emphatically a *national man.*

On the 14th of December, 1873, Agassiz passed from the scene of his earthly labors to another and a wider sphere.

The elite of the nation attended the impressive funeral services in the chapel of Harvard University. The mournful sound of the tolling bells seemed to give expression to the heavy gloom which rested upon the large gathering and the entire city.

Well might the flags of the country descend to half mast and mourn so useful a citizen. Well might the representative men of the American Government and of cultivated society mingle their sorrow with that of the representatives of science and public education, for which he had done so much.

On his modest tomb, in Cambridge, under the hallowed shades of Mount Auburn Cemetery, a huge boulder of solid granite, transported from the glacier of the Aar, the theatre of his glorious investigations, fitly marks the resting place of his mortal remains; but Agassiz's memory will live in the hearts of all those who have known him well, and his name will shine forever in a high place in the Temple of Science.

MEMOIR

OF

JEFFRIES WYMAN.

1814-1874.

BY

A. S. PACKARD.

Read before the National Academy, April 18, 1878.

BIOGRAPHICAL MEMOIR OF JEFFRIES WYMAN.

Mr. President and Gentlemen of the Academy:

In reviewing the life and works of Jeffries Wyman we shall consider his contributions to comparative anatomy and physiology, and to palæontology, as well as to ethnology and archæology. We mention these sciences in the order in which he took them up, since Wyman began his life's work as a comparative anatomist and physiologist, and in his riper years ranked as an anthropologist of a high order, his wide range of biological studies peculiarly fitting him for doing work of an unusual degree of excellence in the science of man, which may well be regarded as the synthesis of the biological sciences.

In all the sciences to which reference has been made his studies were pursued with a thoroughness, ease, and accuracy of treatment, a breadth of view, and general philosophic grasp which proved him to be second to few in those peculiar gifts which mark original investigators of the highest order.

While Jeffries Wyman possessed a quality of mind that allied itself to genius, together with the patience and unwearied devotion to work which accompanies what we usually understand by that term, his mind was of the judicial order, and he was too equably developed intellectually to show that brilliancy and special aptitude in a single direction to be classed as a "genius." The reverse of erratic or doctrinaire, never one-sided in his views of a subject, he weighed every problem which presented itself to his mind with the exact methods of the physicist and chemist, combined with the exercise of the peculiar gifts of the biologist.

Wyman never allowed himself to be mastered by a guess; to follow his intuitions beyond the point they naturally led. On the contrary, he proved all things by repeated experiments. He once said to the writer, "One experiment alone proves nothing." He fully possessed the spirit of modern science. His characteristic

traits as a man and scientist were extreme truthfulness, accuracy, equipoise, and modesty. He was reticent in publicly expressing his views on those problems of life unanswerable by the science of his day and of ours. On the other hand, he was courageous in his private convictions on ultimate questions, stepping to the very edge of the precipice overlooking the speculative, misty depths below.

As a friend and companion, light-hearted, genial, warm in his affections, unselfish, and thoroughly unassuming, Wyman has left a memory to be revered and loved. And it is a rare privilege and pleasure to recall the features of his high moral and intellectual worth, to trace his scientific development, and to review the results of a life so wholly devoted to the advancement of a knowledge of nature for its own sake.

Jeffries Wyman* was the third son of Dr. Rufus Wyman and Ann Morrill, daughter of James Morrill, a Boston merchant.

Dr. Rufus Wyman, says Professor Gray, was a man of marked ability and ingenuity. He was born in Woburn, Mass., graduated at Harvard College in 1799, and in the latter part of his life was physician to the McLean Asylum for the Insane at Somerville, Mass.

An older brother of Jeffries, who was the third son, is Morrill Wyman, distinguished as a physician, and author of various medical works, and for his warm interest in science. He, with another brother, Edward, a merchant in Boston, are the survivors of a family of five—four brothers and a sister. Jeffries derived his baptismal name from the distinguished Dr. John Jeffries, a Boston physician, with whom his father studied medicine.

The subject of our memoir was born August 11th, 1814, at Chelmsford, a small town situated near the present city of Lowell. When he was at the age of four his father removed to the McLean Asylum at Somerville. In his early boyhood he attended a private school at Charlestown, but afterwards attended the academy at Chelmsford.

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* The biographical facts here given are mainly taken from the memorial address of Professor Asa Gray, delivered October 7th, 1874, before the Boston Society of Natural History, and printed in its proceedings, vol. xvii, pp. 95–124; also Dr. Oliver Wendell Holmes: "Professor Jeffries Wyman, a Memorial Outline," in the Atlantic Monthly, November, 1874. Other notices are by Professor B. G. Wilder, in "Old and New" and the Popular Science Monthly, and by Professor F. W. Putnam, in the Proceedings of the American Academy of Arts and Sciences, Boston.

The following extract from a letter from his brother, Dr. Morrill Wyman, to Dr. Holmes will recall his tastes and preferences as a boy:

"He early showed an interest in natural history. When less than ten years old he spent half his holidays in solitary walks along the banks of the Charles river and the margin of the creek near the asylum to pick up from the sedge anything of interest that might be driven ashore. It was seldom that he returned from these walks without something, either dead or alive, as a reward of his search. In college the same preference continued, and, although he did not neglect the prescribed course, he made many dissections and some skeletons, especially one of a mammoth bull-frog, once an inhabitant of Fresh Pond, which was a subject of interest to his classmates, and is now, I believe, in his museum of comparative anatomy. He early commenced drawing, but with very little regular instruction. He also, when ten or twelve years old, painted on a panel with house paints a portrait of himself, which was something of a likeness, but deficient in proper tints. The nearest approach he could make to the color of his hair was green. His facility in sketching in after life was remarkable. He drew anatomical subjects with great accuracy and rapidity. His drawing upon the black-board, in illustrating his lectures, done as it was as he lectured, was most effective. His diagrams for his lectures to the under-graduates of Harvard College were nearly all drawn and colored by his own hand."

Wyman was fitted for college at Phillips Exeter Academy, then presided over by the distinguished Dr. Abbot.

The impression young Wyman made while a pupil at this famous school upon his fellow-students is recorded in a letter to Dr. Holmes by Professor Bowen, who, after speaking of him when a boy of fourteen as "pure-minded, frank, playful, happy, careless, not studious, at least in his school-books, but not mischievous," added: "He *would* take long rambles in the woods and go into the water and a-fishing, and draw funny outline sketches in his school-books, and whittle out gimeracks with his penknife, and pitch stones or a ball farther and higher than any boy in the academy, when he ought to have been studying his lessons. Only a few years ago, when we were chatting together about our early life at Exeter and in college, he said, in his frank and simple way, with a laugh and half a sigh:

'Bowen, I made a great mistake in so neglecting distasteful studies, though you may think I made up for it by following the bent of my inclinations for catching and dissecting bull-frogs. I have been obliged, even of late years, to study hard on some subjects distinct from and yet collateral with my especial pursuits, which I ought to have mastered in my boyhood.' The boy was very like the man, only with age, as was natural, he became more earnest, persistent, and methodical."

"One need not be surprised to learn," adds Dr. Holmes, from "another class-mate, himself distinguished as a scholar, that many of those whom Jeffries Wyman distanced and left out of sight in the longer trial of life stood above him in scholarship during his college course."

Entering Harvard College in 1829 he graduated in 1833 in a class numbering fifty-six, five of whom besides himself afterward became professors in the University.

Professor Gray remarks that young Wyman, while in college, "was not remarkable for general scholarship, but was fond of chemistry, and his preference for anatomical studies was already developed. Some of his class-mates remember the interest which was excited among them by a skeleton which he made of a mammoth bull-frog from Fresh Pond, probably one which is still preserved in his museum of comparative anatomy. His skill and taste in drawing, which he turned to such excellent account in his investigations and in the lecture-room, as well as his habit of close observation of natural objects met with in his strolls, were manifested even in boyhood."

Under the old regime (with the restricted curriculum and iron-clad system of the college of the first half of this century) such unwonted aptitudes and turn of mind as distinguished young Wyman were certainly not fostered; on the contrary, such growths were considered as abnormal, almost pathological, and were unconsciously, or with intention, removed or frowned upon. With little chemistry and less physics, a smattering of astronomy, but no physiology, botany, zoölogy, or geology, for those sciences were then *in embryo*, and even the first germs considered by most pedagogues as pernicious; the microscope not then in general use, and no laboratory open for experiment—no wonder the limited range of studies then pursued had slight attractions for the inquiring mind,

the ingenuity in manipulation, and the overmastering love of external nature so predominant in that college boy.

Fitted neither by temperament nor bodily health for the exacting duties of the clerical, medical, or legal professions, the future physiologist and anatomist, who was to become so distinguished as a college professor as well as investigator, had inherited a native ability which supplied the place of severe labor in uncongenial studies. If in these times the legal profession as well as the medical or clerical demand the most careful preparation in the limited range of studies of the olden time, certainly none the less honorable or less liberal are those studies in the physical, natural, and psychological sciences, which are now open to those who would become professional physicists, physiologists, botanists, zoölogists, geologists, or astronomers. These professions are now regarded as fairly abreast those of theology, medicine, or law. All are learned professions, and equal in honor and usefulness to mankind.

During his senior year in college young Wyman suffered from a dangerous attack of pneumonia, which, says Dr. Holmes, "seems to have laid the foundation of the pulmonary affection that kept him an invalid, and ended by causing his death." To recover from the effects of this attack he spent the winter of 1833–'34 in the Southern States, and this flight southward at the approach of winter was but the precursor of many others.

The following spring Wyman began his medical studies under Dr. John C. Dalton, who had succeeded his father at Chelmsford. For the two following years he divided his time, given to earnest study, between his medical teacher, his father, and the Medical College in Boston. In the third year of his medical course he was house physician in the medical department at the Massachusetts General Hospital, finally receiving (1837) the degree of doctor of medicine. His graduation thesis was upon the eye, and the results were probably in part embodied in his essay entitled "Indistinctness of Images Formed by Oblique Rays of Light," published in September of the same year.

After graduation he rented an office in Boston on Washington street, and performed the duties of demonstrator of anatomy, under Dr. John C. Warren, then well known as a comparative anatomist.

These situations were far from remunerative, and Dr. Gray tells us that, "in order to eke out his subsistence, he became at this time a member of the Boston Fire Department, under an appointment

of Samuel A. Eliot, mayor, dated September 1, 1838. He was assigned to engine No. 18. The rule was that the first-comer to the engine-house should bear the lantern and be absolved from other work. Wyman lived near by, and his promptitude generally saved him from all severer labor than that of enlightening his company."

But it was in lighting the hidden ways of nature that our associate was to devote his life rather than to practicing the healing art. He turned from physic to pure science. "Excellent as he would have been as a physician, welcome as his gentle voice and pleasant smile would have been at the bedside, keen as he would have been in detecting the nature and causes of disease, and conscientiously assiduous as he would have shown himself in doing all he could to alleviate it, many of his most precious natural gifts would never have found a full opportunity of exercise if he had not followed the course for which nature had marked him out from his boyhood."*

If the studies open to young Wyman at the preparatory school and college were not such as to immediately bear upon his future profession, there is little doubt but that the training of the eye and of the reasoning powers in the medical school and the hospital was the best education then open to one destined for original research and for logical, clear exposition of biological phenomena and laws. Fortunate in his birth and early surroundings, young Wyman was fortunate in his medical advisers and teachers. The atmosphere he breathed in Boston was not alone a medical one, but pervaded by high scientific aims and warmed with a zeal for scientific discovery. If a chill penury repressed the dreams of his youth, and his immediate prospects of getting a livelihood were discouraging, he was even then rich in the unseen influences of friendship and regard of men like Dr. J. C. Warren, Mr. John A. Lowell, and others,† who, if

* Dr. Oliver Wendell Holmes, Atlantic Monthly.

† "Of penury in a literal sense we may not speak, for although Prof. Wyman's salary, derived from the Hersey endowment, was slender indeed, he adapted his wants to his means, foregoing neither his independence nor his scientific work, and I suppose no one ever heard him complain. In 1856 came unexpected and honorable aid from two old friends of his father, who appreciated the son and wished him to go on with his scientific work without distraction. One of them, the late Dr. William J. Walker, sent him ten thousand dollars outright; the other, the late Thomas Lee, who had helped in his early education, supplemented the endowment of the Hersey

they themselves could not take it up, appreciated the scientific life, with its intellectual and moral triumphs, its consecration to truth for its own sake, its high ideals. Such friends as these opened the gate to those pleasant, peaceful paths of pure scientific research along which Wyman was to walk the remainder of his days, spotless from the stains of ambition, jealousy, and self-seeking which have marked too many scientific careers.

The Lowell Institute was the result of the scientific spirit already aroused in Boston and vicinity, which made that city only second, in the first half of the century, to Philadelphia as a scientific centre. Mr. John A. Lowell, who administered the affairs of this institution, offered Wyman the curatorship of it. In the winter of 1840–41 he delivered a course of twelve lectures upon comparative anatomy and physiology.

The proceeds of these lectures enabled him to spend part of a year in Europe, his stay, however, being shortened by the illness and death of his father.

Paris was then the scientific centre of Europe, though Cuvier, a few years previous its central figure, had passed away.

Though he seemed to have given some time to human anatomy at the School of Medicine we may feel sure that a larger portion saw him in the lecture-rooms of the physiologists, Flourens, Majendie, and Longet, as well as those masters in zoölogy and comparative anatomy, De Blainville, Isidore St. Hilaire, Valenciennes, Dumeril, and Milne-Edwards.

When the lectures were over he made a journey on foot along the banks of the Loire, walked down the valley of the Rhine, thence through Belgium, and by steamer to London, where he made the personal acquaintance of Professor (now Sir) Richard Owen, then in charge of the Hunterian Museum of the Royal College of Surgeons.

In 1843 he was appointed to the chair of anatomy and physiology in the medical department of Hampden Sidney College at Richmond, Va. Here he spent the winter and spring months for five years, spending the summer and autumn at his northern home,

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professorship with an equal sum, stipulating that the income thereof should be paid to Prof. Wyman during life, whether he held the chair or not. Seldom, if ever, has a moderate sum produced a greater benefit."—*Dr. Asa Gray's Memorial Address.*

until in 1847 he was called to succeed Dr. Warren as Hersey professor of anatomy in Harvard College. He soon became established in Boylston Hall, with a suitable museum, lecture, and work rooms. Here he delivered his weekly lectures on comparative anatomy and physiology to the senior class, and gave advanced instruction in human and comparative anatomy to special students, many of whom are among our leading physicians, surgeons, and scientists. His leisure hours were devoted to building up his museum, where neatness, order, and system prevailed. It was an education to walk by the cases. As the collection has been removed, and now incorporated in that of the Boston Society of Natural History, we will let the graphic, facile pen of Dr. Holmes, then his friend and colleague in the medical school, portray the appearance of this unique collection, the work of his own hands, brought together by his almost unaided exertions, without grants from public or private funds:

"We enter the modest edifice known as Boylston Hall, and going up a flight of stairs find a door at the right, through which we pass into a hall extending the whole length of the building. The tables in the centre of the floor, the cases surrounding the apartment, and the similar cases in the gallery over these are chiefly devoted to comparative anatomy. Above the first gallery is a second devoted to the archæological and ethnological objects, which make up the Peabody Museum. The fine effect of the hall and its arrangements will at once strike the observer. In the centre of the floor stands the huge skeleton of a mastodon found in Warren county, New Jersey, in 1844. Full-sized casts of the 'fighting gladiator,' as it was formerly called, and the Venus of Milo stand at the two extremities of the hall, and one of the Venus de Medici opposite the door. Stretched out at full length in glass cases are the anatomical wax figures, male and female, which used of old to be so wondered over by the awe-struck visitors who had gained admission into little Holden Chapel. The skeletons of a large alligator and of an overgrown anteater; a rattlesnake of fearful size and aspect and a youthful sawfish, both in alcohol; a slab with fossil foot-prints from the Connecticut river valley, and cases of separate bones from the four animal kingdoms are the other principal objects grouped about the mastodon.

"In the cases around the room are great numbers of fine skeletons of man and various animals, among them of the jaguar, the ostrich, the boa-constrictor, and of immense sea-turtles. Most interest-

ing of all are the skull and other bones of a mighty gorilla. His head and pelvis are far from human in their aspect, but his arm-bone is so like that of his cousin-Darwinian, that it looks as if it might have belonged to Goliath of Gath, or Og, king of Bashan. The skeleton of a young chimpanzee, by the side of that of a child, has a strongly marked effect of similar significance. There are whole series of special preparations to show the parts of the skeleton concerned in locomotion in different classes of animals

"The cases in the gallery contain a vast number of wet and dry preparations, of which a very few may be indicated. One of Prof. Wyman's last labors was to refill the jars of the wet preparations with alcohol, and they are in excellent condition. Among these are many careful dissections of the nervous centres and the organs of sense and a series of embryological specimens, which cannot fail to arrest the most careless observer. There are the Surinam toads, with their ova on their backs, like potatoes in their hills; there are strange fishes, with their mouths full of eggs; there is the infant skate, with a broad laugh on his face as if he thought it a good joke to have been hatched and forthwith drowned in proof spirit, like Clarence in his butt of malmsey. Then come monstrosities of various kind and degree, wonders, and nothing more to the vulgar—keys to some of nature's deepest secrets to the man of science. We pass next to the nests of wasps and hornets and the combs of bees, with casts of the cells, from some of which, it may be mentioned, Prof. Wyman took impressions directly upon paper, thus insuring that accuracy for which he was almost unrivaled. The nests of the great ants will next attract the eyes of the curious, and near these the wonderful carpentry of the beavers, as shown in the sticks they have cut into lengths as if with tools of human workmanship; the great chisels of the rodents, those enamel-shaped incisors, which are so contrived as to keep their sharp bevel by the mere wear of use, grin in the crania ranged in rows above; and so we might go on through almost innumerable specimens filling the shelves—not with the rubbish of cheap collections, but with objects each of which has an idea behind it and each important series of which has been illustrated by a paper well known to the scientific world."

While his museum was enriched by preparations of specimens gathered at or near home he added largely to its resources during his travels abroad. His first journey out of the country was in the summer of 1849 to the coast of Labrador, obtaining the means for the trip by

a second course of lectures upon comparative physiology before the Lowell Institute. These were published from the condensed shorthand notes, with diagrammatic figures, as a thick pamphlet, which was the nearest approach to a general work which Wyman could ever be induced to publish, although in after years urged to prepare a manual on that subject.

The winter of 1852 was spent in Florida. Driven there by ill-health he yet found time and strength to begin his examination of the shell heaps of that region, which from time to time were renewed, the rich material thus collected forming the subject of a volume whose proof-sheets he did not live to read. The winter of 1854 was devoted to traveling in Europe, visiting museums and scientific men.

His most fruitful journey, amid scenes he would often recall with keen delight, was that to Surinam. Leaving Cambridge in the spring of 1856, accompanied by his pupils, Green and Bancroft, we may be sure that immediately upon landing he visited the fish market of Surinam in search of Anableps, to whose unusual mode of gestation his attention had been called two years previous by Dr. Cragin, once United States consul at Paramaribo. In his canoe journey up the Surinam river, besides other objects, he collected specimens of the Surinam toad, whose singular metamorphoses he described. These were the *optima spolia* of this journey, though the Indians of the country must have been critically scanned with his observant, trained eye. But his opportunities for extensive study and exploration were hampered by a severe attack of the fever of the country, from which he recovered slowly.

In 1858–9 he made a voyage, as the guest of Capt. J. M. Forbes, to the La Plata, ascending the Uraguay and the Parana in a small iron steamer. Thence, with his friend, Mr. G. A. Peabody, of Salem, Mass., he crossed the pampas to Mendosa and the Cordilleras to Santiago and Valparaiso, returning home by way of the Peruvian coast and the Isthmus of Panama.

His later field work was confined to the glades of Florida and to expeditions along the coast of Maine and Massachusetts, where he investigated the Indian shell heaps, visiting twenty-five different localities and selecting from them several thousand specimens.

His connection with the Boston Society of Natural History was almost life-long—he joined the society in 1837; from 1839 to 1841 was its recording secretary; from 1841 to 1847 filled the office of

curator of ichthyology and herpetology, of herpetology alone from 1847 to 1855, was curator of comparative anatomy from 1855 to 1874, and was its president for fourteen years, from 1856 to 1870. At the meetings of this society Wyman often presented in brief form the results of most of his biological investigations, the number of his communications amounting to one hundred and five. Of these, many which occupied a goodly portion of the evening in their delivery, are unfortunately represented by brief abstracts of but a few lines in length.

As a presiding officer Wyman showed tact, dignity, and efficiency. His store of varied information, often drawn upon, seemed unfailing, and his simplicity and directness of diction were marked.

As a college lecturer Wyman was clear, simple, and attractive. He used brief notes on a slip of paper, drawing with facile hand on the blackboard. Never aiming at effect, unrhetorical, his method and manner were stamped not only with the air but the reality of truthfulness. The weekly Saturday lecture was a rare treat, and his lectures were models of their kind.

Wyman's skill in planning methods and performing experiments was noticeable. The years in which he taught were before the days of a complicated anatomical technique and of chemical reagents, hardening processes, staining with various animal and vegetable dyes, and of section cutting, but Wyman was inferior to no one in inventive skill and ingenious devices. One of these was his method of demonstrating the motive power of cilia. The apparatus is described in his paper, entitled "Experiments with Vibrating Cilia," and was a delicate and skillful device for rendering the effects of ciliary movements visible in a large lecture-room. In his memorial notice of Jeffries Wyman, contributed to the Popular Science Monthly, Prof. B. G. Wilder recalls an apparatus for demonstrating the entire circulation, arterial, venous, and capillary, an account of which was never published.

Although a comparative anatomist and embryologist, contributing to science memoirs of classical worth, and strong in the field of morphology, we much doubt whether Wyman would have allowed himself to have been called a "morphologist" or a "biologist," or have allowed the name of "morphological laboratory" to be applied to his workshop, however useful such an appellation may now be regarded in some quarters. He avoided the use of polysyllabic Latin or Greek words if plain English would answer the purpose.

The reverse of pedantic, prolix, or prosy, he was intolerant of these defects in others. We well remember in the council meetings of the Boston Society of Natural History his protest against using in the printed lists of the offices such titles as "curator of mammalogy" or of ichthyology, preferring the simpler English terms "curator of mammals," "fishes," etc.

Wyman did little work in systematic zoölogy. In his simple but decisive way he once expressed to the writer his scorn of nomenclature, and, half in earnest, half in jest, declared that it would be better to drop the use of scientific binomials and to designate species simply by numbers—and those were before the day of trinomial or polynomial appellations.

Whether this habit of mind was the result of his exact and detailed studies, and the desire to express in few, well-chosen words just what he saw, and to present his inductions in a terse, epigrammatic form, or whether his ill-health and ordinary museum drudgery left him little time, Wyman failed to write out at length his results with detailed consideration of all the facts and their relations leading to them. In after life he saw his mistake, and in the kindly, friendly, frank way he had with his young friends told the writer that he had erred in not writing out at greater length his observations and publishing them in more complete manner, with elaborate illustrations.

Here his modesty and reticence stood in his way. His delicacy and tact, as well as his self-respect, made controversy and claims for priority foreign to his wishes. And after all it is a waste of time, a squandering of intellectual power, to indulge too freely the simple desire for mastery in a contest, though in debates and disputations new views may often be elicited. Throughout Wyman's writings we shall look in vain for a claim for priority, a reclamation, or a wordy dispute. He was content in a too brief abstract to announce his conclusions, based perhaps on weeks and months of laborious experiments or dissections, and to leave to the naturalists of the future to judge as to the merits of his work.

"If he had ambition," writes Dr. Holmes, "it was latent under other predominating characteristics. So far as could be seen his leading motive was an insatiable, always active, but never spasmodic, desire of learning some new secret of nature. If a discovery came in his way he told of it without any apparent self-applause or vanity. He, who never made blunders, might fairly be indulged

in a quiet smile at those of his neighbors, but he was considerate with scientific weaklings, and corrected them as tenderly as Isaac Walton would have the angler handle his frog."

"He never took part in any controversy," wrote Mr. Alexander Agassiz to Dr. Holmes, who adds that "on one occasion, to which Mr. Agassiz refers, when he was unfairly treated by a leading man in science, 'he never complained of it or even mentioned it;'" and Mr. Agassiz added: "Unless he could add something of importance to the memoirs of his predecessors he never allowed himself to print his observations if they were mere confirmations. At the time Owen and the younger Milne-Edwards published their memoirs on the dodo he had been at work for a long time on the same material in the Museum of Comparative Zoölogy, and was just ready to commence; yet he was satisfied in criticising a few points in the above papers, and returned the series of bones, all carefully labeled, saying he should have no further use for them."

Writes Dr. Weir Mitchell in Lippincott's Magazine:

"Everywhere, indeed, his letters, which made the most of our intercourse, were full of the broadest sympathy in pursuits which often were—but often were not—in the same direction as his own life-long studies. At times, too, the sympathy broke out into the extreme of generosity. Thus, having learned from me that certain very important and hitherto undescribed anatomical structures would probably be found in serpents and frogs, he tells me soon after that he has found them; also that he has discovered them in birds, and that he has been led finally to a series of unlooked-for discoveries in the anatomy of the nerves of the frog; and he wishes experiments made on living frogs to learn the physiological use of the structures thus found. Then not long after he proposes that, as the first discovery came from this writer, he should take and use the notes and drawings which recorded his own researches, and should use them in a second paper. It is needless to say that this was declined, and the results appeared under Wyman's name. It was characteristic of the man, and was not the only time when I had to thank him for the kindest offers of aid."

Having considered Wyman's career as a student of medicine, also the period covering about twenty years during which he actively taught and built up with his own hands a large and well-arranged museum of comparative anatomy, we are brought to the third and

last epoch in his life, in which he founded and elaborated a second grand collection—the Peabody Museum of American Archæology and Ethnology.

With his previous studies in human and comparative anatomy, besides physiology, his widespread explorations of Indian mounds, his studies of skeletons and crania, and his increasing interest in the study of the physical history of man, as well as the extensive collections which overcrowded the shelves in Boylston Hall—with all these favorable presages the fullness of time had come for the creation of a new museum and department in Harvard College. And when in 1866, by the beneficence of the late George Peabody, the philanthropist, such a museum and department of instruction was founded, Jeffries Wyman was named as one of the seven trustees of the museum and professorship, and, as was most natural and befitting, he was appointed by his associate trustees to the curatorship of this rapidly increasing collection. It goes without saying that Wyman was the best equipped man in America for the task before him. Morton had passed away, and no one since Wyman's time has filled the latter's place as a student of crania and a general ethnographer, though in archæology, perhaps an easier field, there are worthy successors. What rare opportunities, means, and facilities for work now opened up before him. And though struggling with declining health, often obliged to forego all work, in the seven annual reports which he left, the last one published just before his death, and in the elaborate memoir on the shell heaps of Florida, with its ethnographical and archæological riches, we have but the earnest of what he might have accomplished with a more robust constitution.

Dr. Holmes tells us in his inimitable way how he went about these duties: "He entered with the enthusiasm of youth upon the duties of the office. What he accomplished in the way of personal contributions, obtaining donations, making judicious purchases, classifying, distributing, arranging, describing, repairing, labeling, the visitor whom we have supposed to have walked around the gallery would not expect to be told within the limited compass of these pages. How many skulls broken so as to be past praying for he has made whole, how many Dagons or other divinities shattered past praying to he has restored entire to their pedestals, let the myope who can find the cracks where his cunning hand has joined the fragments tell us. His manipulation of a fractured bone from a

barrow or a shell-heap was as wonderful in its way as the dealing of Angelo Mai with the scraps of a tattered palimpsest."

As emphatically stated in 1874 by Dr. Asa Gray, "If this museum be a worthy memorial of the founder's liberality and foresight it is no less a monument of Wyman's rare ability and devotion. Whenever the enduring building which is to receive it shall be erected surely the name of its first curator and organizer should be inscribed, along with that of the founder, over its portal." We may feel sure that all that affection and justice could do has been accomplished by the present authorities. Since Wyman's death the monument has been erected, one worthy of its founder and organizer, and one worthy of comparison with others of its kind in the Old World.

Wyman's labors under these new circumstances were constantly and for long periods interrupted by ill health. Several winters were spent in Florida and one in Europe. The winter before his death was passed in Florida, with some temporary benefit to his health, and during the summer of 1874 the work which he accomplished in his museum "might have tasked a robust man." Late in August of that year he left Cambridge for his usual visit to the White Mountains, to avoid the autumnal catarrh; but while at Bethlehem, on the 4th of September, he suddenly died from the effects of a hemorrhage from the lungs.

Professor Wyman was married in December, 1850, to Adeline Wheelwright, by whom he had two daughters. She died in June, 1855. In August, 1861, he married Anna Williams Whitney, who died in February, 1864, soon after the birth of a son, who bears his father's name.

Professor Wyman was from 1843 an active Fellow of the American Academy of Arts and Sciences in Boston and a member of its council for many years. He was elected president of the American Association for the Advancement of Science for the year 1857; but, whether from a disposition which led him to avoid publicity or from ill-health, he did not perform the duties of that office. He was, however, treasurer of the first meeting, held in 1848, was secretary of the second meeting, and about the year 1856 made two communications to that body. He was also one of the original members of the Association of American Geologists and Naturalists, held in Boston in 1847, and read that year before this learned body an account of the gorilla. Appointed by Congress as one of the

original members of this Academy, he resigned the position, but his name remains on its roll as an honorary member. He was also one of the faculty of the Museum of Comparative Zoölogy at Cambridge.

It remains for us now to call attention to the more important results of Wyman's life's work, as recorded in his scattered papers and memoirs.

Besides notes on the formation of ripple marks and on the morphology of the leaves of Sarracenia, Wyman's few purely zoölogical observations were made on parasitic worms, on the fresh-water sponge, the species of fishes from the Surinam river, the larvæ of *Dactylethra capensis*, the white whale, on the localization of species, on amœba, amphioxus, the habits of spiders, of wasps; his only contributions to systematic zoölogy being descriptions of a new species of torpedo, new species of intestinal mites and worms, a new species of Manatus, and a description of the gorilla.

In the domain of comparative embryology his minor notices related to the formation of the egg-case of skates, the habits of the Scaphiopus toad, the mode of formation of the rattle of the rattlesnake, on eggs of salamanders, the development of the human embryo, and the mode of impregnation of the ova in Pomotis.

His papers on Anableps added much that was novel to the interesting subject of unusual modes of gestation in viviparous fishes. In the markets at Surinam he found seven species of these fish, the males of which had their mouths "crammed to the fullest capacity" with the eggs which the females had laid. He supposed that the eggs must be disgorged while the animals were feeding. Of equal interest, in their relations to the evolution theory, are his observations on the Surinam toad, whose young are provided with small gills, which, however, are of no use to them, as the tadpoles do not enter the water, but are carried about in cavities on the mother's back, where they are placed by the male at the time they are fertilized. The female then enters the water, the skin thickens, rises up around each egg, closing over it, thus forming a marsupial sack or cell. The young pass through their metamorphosis in the sacks, having tails and rudimentary gills; these are absorbed before they leave their cells, the limbs then develop, and the young leave their cells in the shape of the adult Pipa.

Wyman's most important embryological treatise was on the development of the skate (*Raja batis*). The condensed results, state-

ments, and conclusions fill but a dozen quarto pages, but these, with the wide anatomical knowledge and reading displayed, render it a paper of first-rate importance, even though much fuller treatises on the embryology of the Elasmobranchs, have since been made by Balfour and others. In considering the origin and disappearance of temporary organs, Wyman's mind ranged through the animal series for unusual, almost inexplicable, phenomena, and if at that date light had not been thrown upon the subject by the doctrine of evolution and the great mass of knowledge we now possess as to rudimentary or temporary structures he, by their orderly arrangement, could call them up, and thus only fall short one degree of a theoretical explanation. This may be seen by the following extract, in which he refers to the anal fins of the skate, which appear only to be absorbed and wholly removed before the end of gestation: "This development, temporary existence, and early removal of the anal fins gives us another interesting example of the formation of parts which have no obvious use in the economy, and which must be regarded as having merely a morphological value. It falls into the same category with the caudal fin of the embryo of Pipa, which is never used, the teeth of certain cetaceans, the inferior incisors of the female mastodon, which are all removed without being used, and the milk incisors of the Guinea pig, which are shed *in utero*."

The results of this masterly treatise are thus stated by the author:

"1. The yelk case is formed in the glandular portion of the oviduct and is begun previously to the detachment from the ovary of the yelk which is to occupy it.

"2. The embryo, before assuming its adult form, is at first eel-shaped and then shark-shaped.

"3. The embryo is for a short time connected with the yelk by means of a slender umbilical cord; the cord afterwards shortens, and the young skate remains in contact with the yelk until the end of incubation.

"4. There are seven branchial fissures at first; the foremost of these is converted into the spiracle, which is the homologue of the eustachian tube and the outer ear canal; the seventh is wholly closed up and no trace remains; the others remain permanently open.

"5. There are no temporary branchial fringes or filaments on the first and seventh arches; on the others the fringes are devel-

oped from the outer and convex portion of the arch, and are not at first prolongations of the internal gills.

"6. The nostrils, as in all vertebrates, consist at first of pits or indentations in the integuments; secondly, a lobe is developed on the inner border of each; and, finally, the two lobes become connected, and thus form the homologue of the fronto-nasal protuberance. The transitional stages of these correspond with the adult conditions of them in other species of selachians.

"7. The nasal grooves are compared with the nasal passages of air-breathing animals, and the cartilages on either side of these to the maxillary and intermaxillary bones.

"8. The foremost part of the head is formed by the extension of the facial disk forward; while this extension is going on the cerebral lobes change their position from beneath the optic lobes to one in front of them.

"9. Two anal fins, one quite large and the other very small, are developed, but both are afterwards wholly absorbed.

"10. The dorsals change position from the middle to the end of the tail. At the time of hatching, however, there is still a slender terminal portion of the tail, which is afterwards either absorbed or covered up by two enlarged dorsals, as they extend backwards."

For the primitive caudal fin Wyman suggested the name protocercal, and he discovered that it "does not at any period assume the heterocercal form, but retains permanently its primary embryonic or protocercal condition."

In palæontology an early paper brought Wyman's name before the public in a way thus related by Dr. Holmes:

"One of his earlier publications in comparative anatomy and palæontology made the name of Wyman known to many outside of the scientific world. This was his paper on certain fossil animal remains which were for a time on public exhibition in Boston. They consisted of a chain of vertebræ, one hundred and fourteen feet long, a few ribs, and portions of what were said to have been the paddles. This formidable antediluvian, obtained by a Mr. Koch from the marly limestone of Alabama, was christened by the name *Hydrarchus Sillimani*, and was advertised as an extinct form of sea-serpent. Dr. Wyman showed conclusively that the "king of the waters" was no reptile at all, but a warm-blooded mammal; that the bones were never parts of one and the same individual

creature, and that some at least of the so-called paddles were casts of the cavities of a chambered shell."

That singular form, the *Castoroides ohioensis*, found fossil in Ohio and the southern Mississippi valley at Memphis, and remarkable not only as being the most gigantic rodent, recent or fossil, was described by Wyman in a joint paper by Prof. James Hall and himself.

While living at Richmond, Va., Wyman described and figured the remains of sharks, skates, reptiles, seals, and cetaceans from the tertiary beds underlying that city. He also reported on the remains of mastodons, both from the Southern States and the Andean plateau at Rio Bamba; upon the Megalonynx and on the vertebrate footprints discovered by Prof. Henry D. Rogers in the carboniferous strata of Pennsylvania. He also described the skull of *Mastodon giganteus* and the form of its brain, the latter a field of research to which of late much attention has been paid by French and American palæontologists.

In the course of their researches on the scaly, reptile-like batrachians or labyrinthodonts of the carboniferous beds of Nova Scotia, Sir Charles Lyell and Mr. (now Sir) J. W. Dawson had occasion to submit to Wyman certain bones. He recognized their reptilian character and prepared descriptive notes of the principal bones, which appeared to belong to two species. The specimens were afterwards taken to London and re-examined by Professor Owen, who confirmed Wyman's inferences, and named the best-preserved species *Dendrerpeton acadianum*. The other species, "originally detected," says Dawson, "by Prof. Wyman, in the specimens brought from the Joggins by Sir C. Lyell and myself," was named *Hylonomus Wymani* by Dawson. He also described a singular labyrinthodont from the carboniferous beds of Ohio, named by him *Raniceps Lyelli*. It was while examining the remains placed in his hands by Sir Charles Lyell that, as Dawson states, he detected, "among the fragments an object of different character, apparently a shell, which was recognized by Dr. Gould of Boston, and subsequently by Mr. Deshayes as probably a land-snail, and has since been named *Pupa vetusta*."* This was at that date the oldest known land-snail.

* The air-breathers of the coal period in Nova Scotia. By J. W. Dawson, LL.D., F. R. S., F. G. S., etc. Montreal, 1863, p. 19.

The larger number of Wyman's papers related to comparative anatomy. Among the more important of his minor articles were brief condensed abstracts of his observations on the brain and spinal cord of Lophius, or the goose fish, and of the lump-fish; on the morphology of the urinary bladder of batrachians, the anatomy of the sharks and of the chimpanzee. He discovered an electrical organ in the tail of the ray (*Raia lævis*). He also gave an account of the anatomy of two land mollusks (*Tebennophorus Carolinensis* and *Glandina truncata*). He devoted much time to certain points in human anatomy. Says Dr. Holmes:

"He has given an admirable description of the arrangement of the spicula of bone in the neck of the human femur, and contrasted this arrangement with that observed in other animals not destined for the erect posture. All his figures of the internal structure of this and other bones of the human frame are, like other illustrations from his own skillful pencil, clear and bold. He knew just what he wanted to show, and his hand obeyed his intelligence. Another article of more popular interest is his description of the brain and cranial cavity of Daniel Webster. Of a more practical bearing is his account of a hitherto unnoticed feature of the two lower lumber vertebræ, dependent on their anatomical peculiarities. In a memorable trial his evidence relating to the bones which had been submitted to great heat is of singular excellence as testimony, and his restoration of the fragments is a masterpiece of accuracy and skill."

But a more elaborate essay was that on the anatomy of the blind fish of Mammoth Cave, Kentucky. Dr. Tellkampf had previously dissected the fish, had detected its rudimentary eyes, and figured the brain, as well as called attention to the "folds on the head serving as organs of touch, as numerous fine nerves led from the trigeminal nerve to them and to the skin of the head generally." In 1853 Dr. Wyman published a description of the eye and ear in Silliman's Journal for 1854. It was a brief paper, but he afterwards turned over to Mr. F. W. Putnam his unpublished drawings and notes, which were incorporated in Mr. Putnam's article in the "American Naturalist" for January, 1872, where he gives especial attention to the nature of the tactile organs on the front of the head. "These papillæ," Wyman states, "are largely provided with nervous filaments, and, as is obvious from their connection with branches of the fifth pair of nerves, must be considered purely tactile, and the large number of them shows that tactile sensibility is

probably very acute, and in some measure compensates for the virtual absence of the sense of sight."

One of his earliest papers (1843) was a curious inquiry into the resemblance between the microscopic character of the teeth of the gar-pike as compared with those of the labyrinthodont batrachians. His description and figures show the close resemblance between the teeth of these forms.

During the same year Wyman began to publish the results of his studies of the higher apes. In his account of the structure of the chimpanzee, in a joint paper by Dr. Savage and himself, he corrected some of Owen's statements. He was the first author to give a scientific description of the gorilla, based on specimens sent him by Dr. Savage. His essay, published in 1847, "contained the essence," says Wilder, "of all that was afterwards published by Owen, who refers to the author as a most accomplished anatomist and physiologist."

Professor Gray refers at length to these studies:

"But the memoir by which Prof. Wyman assured his position among the higher comparative anatomists was that communicated to and published by this society in the summer of 1847, in which the gorilla was first named and introduced to the scientific world, and the distinctive structure and affinities of the animal so thoroughly made out from the study of the skeleton that there was, as the great English anatomist remarked, 'very little left to add and nothing to correct.' In this memoir, the 'Description of the habits of *Troglodytes Gorilla*' is by Dr. Thomas S. Savage, to whom, along with Dr. Wilson, 'belongs the credit of the discovery.' The osteology of the same and the introductory history are by Dr. Wyman. Indeed, nearly all since made known of the gorilla's structure, and of the affinities soundly deduced therefrom, has come from our associate's subsequent papers, founded on additional crania brought to him in 1849 by Dr. George A. Perkins, of Salem; on a nearly entire male skeleton of unusual size, received in 1852 from the Rev. William Walker, and now in Wyman's museum, and on a large collection of skins and skeletons placed at his disposal in 1859 by Du Chaillu, along with a young gorilla in spirits, which he dissected. It was in the account of this dissection that Prof. Wyman brings out the curious fact that the skull of the young gorilla and chimpanzee bears closer resemblance to the adult than to the infantile human cranium.

"In Prof. Wyman's library, bound up with a quarto copy of the memoir by Dr. Savage and himself, is a terse but complete history of this subject, in his neat and clear handwriting, and with copies of the letters of Dr. Savage, Professor Owen, Mr. Walker, and M. du Chaillu.

"In the introductory part of the memoir, Prof. Wyman states that 'the specific name, *Gorilla*, has been adopted, a term used by Hanno in describing the wild men found on the coast of Africa, probably one of the species of the Orang.' The name *Troglodytes Gorilla* is no doubt to be cited as of Savage and Wyman, and it was happily chosen by Prof. Wyman, after consultation with his friend, the late Dr. A. A. Gould, for the reason just stated. But it is interesting to see, in the correspondence before me, how strenuously each of the joint authors deferred to the other the honor of nomenclature. Dr. Savage from first to last insists in repeated and emphatic terms that the scientific name shall be given by Dr. Wyman as the scientific describer, and that he could not himself honestly appropriate it. Prof. Wyman, in his MSS. account, after mentioning what his portion of the memoir was, and that 'the determination of the different characters on which the establishment of the species rests was prepared by me,' briefly and characteristically adds: 'In view of this last fact, Dr. Savage thought, as will be seen in letter, that the species should stand in my name, but this I declined.'

"This memoir was read before this Society on the 18th of August, 1847, and was published before the close of the year. But it had not, as it appears, come to Prof. Owen's knowledge when the latter presented to the London Zoölogical Society, on the 22d of February, 1848, a memoir founded on three skulls of the same species, just received from Africa through Capt. Wagstaff. When Prof. Owen received the earlier memoir, he wrote to compliment Prof. Wyman upon it, substituted in a supplementary note the specific name imposed by Savage and Wyman, and reprinted in an appendix the osteological characters set forth by the latter.

"It does not appear (adds Dr. Wyman) either in the Proceedings or the Transactions of the [Zoölogical] Society at what time our memoir was published, nor that we had anticipated him in our description.

"It is safe to assert that in this and the subsidiary papers of Dr. Wyman may be found the substance of all that has since been

brought forward bearing upon the osteological resemblances and differences between men and apes. After summing up the evidence he concludes:

"'The organization of the anthropoid quadrumana justifies the naturalist in placing them at the head of the brute creation, and placing them in a position in which they, of all the animal series, shall be nearest to man. Any anatomist, however, who will take the trouble to compare the skeletons of the negro and the orang cannot fail to be struck at sight with the wide gap which separates them. The difference between the cranium, the pelvis, and the conformation of the upper extremities in the negro and Caucasian sinks into comparative insignificance when compared with the vast difference which exists between the conformation of the same parts in the negro and the orang. Yet it cannot be denied, however wide the separation, that the negro and orang do afford the points where man and the brute, when the totality of their organization is considered, most nearly approach each other.'"

Another subject, one in transcendental anatomy, was more difficult, but in its treatment Wyman's common sense, tact, caution, and freedom from excess in speculation were conspicuous. This was his thoughtful essay on symmetry and homology in limbs, published in 1867. He thus opens the subject:

"Anatomists who have compared the fore and hind limbs of man and animals have mostly described them as if they were parallel repetitions of each other, just as are any two ribs on the same side of the body. By a few they have been studied as symmetrical parts, repeating each other in a reversed manner from before backwards, as right and left parts do from side to side. We have adopted this last mode of viewing them because, though open to grave objections, as will be seen further on, the difficulties met with are, on the whole, fewer than in the other, and because, too, it is supported by the indications of fore and hind symmetry in other parts of the body."

This subject would seem in part to be metaphysical, and unless treated with careful hands a discussion of it is liable to become tinged with mysticism and scholasticism, and not to be scientifically productive.

Another subject which likewise borders upon what has been called transcendental anatomy is the relation between the vertebrates and

invertebrates. This has been treated in Wyman's best manner in his elaborate treatise on the nervous system of Rana pipiens, published in 1853. His style is comprehensive and yet simple and clear; his decisions sound, judicial; and his views, notwithstanding recent embryological work, especially on the ascidians and Amphioxus, are, it seems to us, well based.

We quote the following passage as an example of his logical style of reasoning and the force and aplomb of his language, and also because the question has again come up for renewed discussion, and Wyman's arguments will hold as well now as thirty-two years since:

"Although frequent attempts have been made to homologize the nervous systems of vertebrates and articulates, yet in reality there seems to exist no correct basis on which the alleged homology may rest. Among the earlier advocates of this view were Gall and Spurzheim, but a more able advocate was found in Geoffroy St. Hilaire. Still more recently the doctrine has been revived, at least, in part. In the recent edition of his General and Comparative Physiology Dr. Carpenter seems to recognize the homology of certain portions, at least, of the nervous systems of articulates and vertebrates, though in others he admits simply an analogy. After stating that there is nothing in the articulates homologous with the cerebrum and cerebellum of the vertebrates, he says: 'The first subœsophageal ganglion, which has been likened to the latter (the cerebellum), being really homologous, as the distribution of its nerves abundantly proves, with the medulla oblongata.'*

"In speaking of the spinal chord he says: 'It consists of a continuous part of gray matter inclosed within strands of longitudinal fibres, and it may thus be regarded as *analogous* to the ganglionic chain of the articulates. If there be any homology, it seems to us as if the whole nervous system of the articulates, as far as it is developed, should be homologous with a corresponding portion of that of the vertebrates. If the subœsophageal ganglion is homologous with the medulla oblongata, that which follows it should be homologous with the spinal chord. There seems sufficient ground for the belief that all homology between the nervous systems of the two divisions is as much contraindicated as between their skeletons or their muscular systems. If a true homology existed we ought at

* Gen. and Comp. Phys., 3d edit., p. 1017.

least to have representatives from the articulates and vertebrates, in which the identity would be obviously proximate, if not absolute. But as yet there has been described no instance where the spinal chord, structurally considered, is fairly and distinctly represented in the articulates, nor among vertebrates any true ganglionic chain with an œsophageal ring through which the œsophagus passes. The existence of separate lateral halves of the spinal chord in the vertebrate embryo has been adduced as evidence of identity. Has there, however, ever been seen an embryo of a vertebrate in which there were developed on the lateral halves of the spinal chord itself distinct and separate ganglionic masses united with the masses above and below? It is true, as already stated, that in many vertebrates distinct enlargements of the chord correspond with the attachments of the different pairs of spinal nerves. But still, in these instances, the chord never loses its vertebrate type. There is always, at least, even in amphioxus, an uninterrupted mass of cell substance occupying the entire length of its centre, and this substance in all other vertebrates is enclosed in two half-sheaths of longitudinal nerve tubes. The likeness recognized between the subœsophageal ganglion and medulla oblongata is *physiological*, but not anatomical; and physiology, all philosophical observers agree, does not teach us homology. The wings of birds and insects, physiologically considered, are corresponding parts, but not so as anatomical structures. On the other hand, the tongue of the giraffe, of the woodpecker, the chameleon, and the lamprey, anatomically considered, are identical parts, are homologous with the organ ordidinarily subservient to taste, but, physiologically studied, are appropriated to widely different uses. Thus the subœsophageal ganglion may be, as regards its functions, the analogue of the medulla oblongata, an analogy, however, which the pure anatomist, independently of experiment, would never discover.

"Professor Owen, in speaking of the interspace in fishes, 'produced by the divarication of the main lateral columns of the encephalon,' through which passes the membranous tube (infundibulum) connected with the hypophysis, asks: 'Is this vertical slit homologous with the encephalic ring perforated by the œsophagus of the invertebrata?'* The homology in this case appears to be opposed by the fact that the slit in question in the fish opens *in front* of the

* Lectures on Comparative Anatomy, vol. II, Fishes, p. 181.

optic lobes, which last, if there be any homology between the nervous systems of the vertebrates and invertebrates, would be the homologues of the supraœsophageal ganglia which give off the optic nerves. The slit should therefore be behind and not in front of these lobes.

"It is contended that the homology between the nervous centres of vertebrates and articulates is contra-indicated by the following facts:

"1st. The brain and spinal chord are enveloped in a common sheath, the vertebral column and its contained membranes, and are never in the same cavity with the viscera, even in the embryo, while the ganglionic chain is lodged and developed in the common cavity with the organs of organic life. 2d. In vertebrates the spinal chord is always on the back and the ganglionic chain always on the abdominal side in the Articulates. 3d. One consists of a continuous mass of both tubular and vesicular structure, while in the other the vesicular structure is interrupted. 4th. The œsophageal ring, with the œsophagus inclosed, never exists in vertebrates, but is always present in the articulates in common with nearly all other invertebrates. 5th. The embryonic conditions of the two systems do not at any period clearly assimilate each other. 6th. Two parts, to be homologous, must be structurally and morphologically similar, and not simply the seat of similar processes."

Work like that on the higher apes and the one under present consideration has placed Wyman's reputation fairly on a level with that of the leading European comparative anatomists. In such work it is quality, and not necessarily quantity, of matter or abundant illustrations which mark a first-rate workman.

We might, in further illustration, quote from the same work what he says as to another debated point in transcendental anatomy which has engaged the attention of morphologists from the days of Oken, Carus, Goethe, St. Hilaire, and the early days of Owen's life. We refer to the vertebrate theory of the skull, regarding which so much has been published by English and German morphologists since Wyman's death:

"The determination of the typical number of cranial nerves becomes a matter of importance in consequence of its bearing upon the philosophical anatomy of the skull. On the hypothesis that the cranium is made up of a series of vertebræ, one of the first questions

which is presented is as to the number which enter into its composition. Throughout the vertebral column, as ordinarily understood, the pairs of nerves equal the number of vertebral pieces. If the cranium is reducible to the vertebral type we might, from analogy, expect that there would be found a series of nerves corresponding in number to the vertebræ of which the cranium is made up. If we admit only such nerves as present the true spinal character to be indicative of the number of vertebræ—that is, those which have motor and sensitive roots, are provided with ganglia, and have a similar mode of development—then, according to the analysis given above, there being three pairs of nerves conforming to the spinal type, we should infer the existence of three vertebræ."

"Anatomists, however, have not generally followed these indications, and it is a singular fact that, in establishing the number of cranial vertebræ, they have rested their conclusions on such widely-different foundations. Oken, in his latest publication, admits the existence of four vertebræ, based on the organs of sense and the lower jaw, and which he designates as the "nose vertebra," the "eye vertebra," the "ear vertebra," and the "jaw vertebra." Bojanus also recognizes four, and substitutes the "tongue vertebra" for Oken's jaw vertebra. Agassiz admitted but a single cranial vertebra, since the chorda dorsalis of the embryo did not extend beyond that portion of the base of the skull which corresponds with the basilar portion of the occiput. Professor Owen, the most recent writer on the subject, who has investigated it very minutely, and has worked out his system with admirable skill, bases his vertebral theory upon the principal subdivisions of the encephalon, from which he deduces a "rhinencephalic," "prosencephalic," "mesencephalic," and "epencephalic" vertebra. A larger number has been admitted by others, as Geoffroy St. Hilaire, Carus, and Maclise, based mainly on an unsound determination of the different osseous elements.

"If we apply the analogies of the spinal chord and vertebral column to the cranium and its nerves we ought to base our determinations on the repetitions of the true spinal nerves and of the true vertebral elements. If the theory be true which reduces the cranial nerves (exclusive of the special sense nerves) to three, namely, the trigeminus, vagus, and hypoglossus, then we ought, *à priori*, to detect at least three vertebral segments. This conclusion agrees perfectly well with the determinations from osteology, for the larger part of modern anatomists admit at least three vertebræ, though

some admit more, but are not precisely agreed as to the exact number of elements which enter into the composition of each. These vertebræ may be designated as follows: 1st, the occipital, of which the basilar bone is the body; 2d, the parietal, of which the posterior sphenoid is the body; 3d, the frontal, of which the anterior sphenoid is the body. Prof. Owen admits a fourth, of which the vomer is the body, and, as this vertebra is associated with the organs of smell, he designates it as the rhinencephalic vertebra. It is through or between these three vertebræ enumerated above that the trigeminus, vagus, and hypoglossus have their exit from the cranial cavity, and it is likewise through or between these same vertebræ that the special sense nerves make their escape. If the number of pairs of nerves of both kinds is to regulate the number of vertebræ then, instead of three pairs, we must admit six for the cranium alone, leaving wholly out of view the face. But if the special sense nerves, for reasons already stated, can be rejected as indications of vertebræ, the cranio-spinal nerves will give us just the number which accords with osteology. In this conclusion we are supported by both osteology and neurology. Johannes Muller admits the existence of three vertebræ, and argues from them the number of pairs of cranio-spinal nerves. 'According to my view there are three vertebral nerves of the head, just as there are three cranial vertebræ. The first is the fifth, or trigeminus; the second is the vagus, with the glosso-pharyngeal and accessory, and the third is the hypoglossus.'

"The three-vertebra theory given above relates simply to the bones constituting the walls of the cranial cavity, which include the brain; no account is taken of the jaws and other bones of the face, nor of the os hyoides. Prof. Owen, in his system, regards these, with the scapular arch, as forming a series of four inferior or 'hæmal' arches to the four cranial vertebræ, with their 'neural arches;' that they, in fact, are serial repetitions of ribs.

"It would be foreign to the purpose of this paper to discuss the grounds on which these conclusions rest. Another hypothesis seems to us worthy of consideration, but which can only be stated in general terms, as follows:

"The teeth in the early embryonic conditions are developed from, and are dependencies of, the mucous membrane of the mouth. In many fishes these conditions are permanent. In rays, sharks, and other cartilaginous fishes the jaws, or other bones which support teeth, are equally developed in the internal integument or mucous

membrane, and are never closely connected with the cranium except by ligament; the hyoid apparatus is likewise developed in the walls of the alimentary canal. If to these facts we add another, namely, that primarily the mouth and nostrils form a single cavity, and are only separated after development has advanced to a certain stage, we have a strong ground for the hypothesis that all the bones of the face, which are developed in the walls of the primitive cavity of the mouth, which they surround, are, in their anatomical and physiological relations, splanchnic, connected either with digestion or respiration, rather than parts of the endo-skeleton of animal life.

"The conclusions which have been drawn from the statements made above are as follows:

"That in frogs the *vagus* comprises the glosso-pharyngeal and accessory nerves; that the *trigeminus* comprises the facial, the abducens, and in the Salamanders the patheticus and portions of the motor-communis; that other evidence sustains the hypothesis that the whole of the motor-communis is a dependence of the trigeminus. If to these we add the *hypoglossus* (which in frogs is exceptionally a spinal nerve) we shall have three pairs of cranial nerves, each having all the characters of a common spinal nerve, namely, motor and sensitive roots and a ganglion; that there are no nerves to indicate a fourth vertebra, unless the special sense nerves are considered. If these are admitted as indications, then we must presuppose either two pairs of nerves to each vertebra or the existence of six vertebræ, which is a larger number than can be accounted for on an osteological basis. The functions and mode of development of the special sense nerves we have taken as affording sufficient grounds for considering them as of a peculiar order, and not to be classified with common spinal nerves."

Another field of research which has engaged the attention of the master-minds in anatomical science is that of teratology, or the description of and explanation of the causes which induce abnormal developments. Among Wyman's minor contributions to this topic are his notes on double-headed snakes, as well as cyclopean and partly-double pigs. But the essay which at once attracted attention, from its ingenious and able attempt to explain the ultimate origin of double monsters, as well as bilateral symmetry in general, was his description of a double human fœtus, published in 1866, in which he came to the following conclusions:

"The descriptions of double monsters by many different observers all show that the tendency is to symmetrical development, so that when an organ ordinarily single becomes double the two organs are always right and left. This is well seen in the specimen just described in the existence of a right and left heart, right and left stomach, spleen, &c. In the cases where organs commonly double are increased in number we may have either a third organ or two entire ones. In the first case the law of symmetry is manifest in a most striking manner, for all such third organs, if not compound in structure, are divisible into right and left halves and half from a different fœtus, and repeating each other oppositely. If, however, they are made up of many parts, as a limb, then the individual parts repeat each other in a smilar way. In the arm already described the muscles repeat and balance each other exactly throughout, and the same is mostly true of the legs.

"The force, whatever it be, which regulates the distribution of matter in a normal or abnormal embryo always acts symmetrically, and if we look for anything among known forces analogous to it it is to be found, if anywhere, in those known as polar forces. The essential features of polarity, as in symmetry, are antagonism, either of qualities or forms. Studying the subject in the most general manner there are striking resemblances between the distribution of matter, capable of assuming a polar condition and free to move around a magnet, and the distribution of matter around the nervous axis of an embryo.

"In every complete series of magnetic curves there are two neutral lines, one extending lengthwise of the magnet, so that the curves formed are divided into right and left; secondly, a transverse one, the particles on each side of which are known as forming the north and south curves. In the right and left series those which are on one side of the magnet are symmetrical with those on the other, but not in themselves; and in the north and south series those on either side of the transverse neutral line are symmetrical with each other, but not in themselves. Thus we have in the first case something analogous to right and left or bilateral symmetry and in the second to fore and hind symmetry.

"If two magnets are placed parallel to each other and at a distance then two complete sets of curves are formed in the usual way, but if they are brought so as to be within each other's influence the magnetic figure now becomes a compound one, the central portion

of which consists of the united curves from the two adjoining sides of the magnet, and the particles from either series of curves do not pass beyond the line where the forces of the two magnets are in equilibrium."

In comparative physiology Wyman's minor notices related to the reproduction of lost parts in planarian worms and other animals on which he experimented, to respiration in beetles, and to the poison of the rattlesnake, which he published in 1860. In that paper he demonstrated the want of direct continuity between the duct of the poison gland and the tooth canal. He explains how the poison is carried from one to the other. A projecting papilla at the end of the duct is held by the gum in close contact with the fang-opening, and when the fang, in rising, thrusts back its mucous cloak this presses so closely upon the parts at the base of the fang as to bring them into perfect opposition.

He also published an account of the mechanism of the tibio-tarsal articulation of the ostrich.

Perhaps his most ingenious and striking work in general physiology is to be found in his novel "Experiments with Vibrating Cilia," published in the "American Naturalist" in October, 1871. He was the first author to call attention to the fact that the force exerted by cilia is unexpectedly great. His attention was first called to the possibility of moving weights much larger than was supposed possible by noticing the ease with which a piece of skin which was accidentally placed upon the ciliated membrane was swept off. By loading the piece of skin with weights the mass moved was found to be unexpectedly large. An ingenious device was therefore planned, which we will let him describe in his own words:

"The mucous membrane being carefully dissected from the roof of the mouth is pinned to a board. A piece of skin from near the throat of the frog, and from one-third to half an inch square, is placed upon this membrane with the inner surface in contact with the cilia, it being kept in mind that these vibrate from before backwards towards the throat. On the skin may be placed a plate of lead of somewhat smaller size. This serves as a vehicle, to which weights may be added at will to increase the load.

"Pains should be taken to have the board on which the experiment is made perfectly horizontal; otherwise a sliding motion, especially when heavy weights are used, may come in to vitiate the experiment."

The rate of movement was determined either by direct observation of the lead "vehicle" with its load or by means of an index attached to the axle of the smaller of a pair of cog-wheels, the "vehicle" being connected with the apparatus by means of a thread coiled round a drum on the axle of the larger wheel. By experiments performed in this way it was found that a weight of thirteen grammes was carried fifteen m. m. in about one minute, the weight resting on a surface of twelve m. m. square, and that "forty-eight grammes, resting on a surface fourteen m. m. square, moved, though very slowly, across the whole length of the membrane; but the exact time was not noted."*

In the broad field of general biology Wyman contributed excellent material. He noticed the effects of the absence of light in retarding the development of tadpoles by keeping those of the bull-frog for seven years in a cellar.

He writes to Mr. Darwin a fact bearing on the correlation between the color of animals and their susceptibility to poison, who reproduces his statement in the "Origin of Species:"

"Prof. Wyman has recently communicated to me a good illustration of this fact. On asking some farmers in Florida how it was that all their pigs were black, they informed him that the pigs ate the paint-root (lachnanthes), which colored their bones pink, and which caused the hoofs of all but the black varieties to drop off; and one of the 'crackers' (*i.e.*, Florida squatters) added, 'We select the black members of a litter for raising, as they alone have a good chance of living.'"

A most admirable research and one thoroughly characteristic of Wyman's mode of working was his essay on the cells of the hive-bee. Here his critical, patient, and in all respects admirable spirit in dealing with a difficult problem are conspicuous. On investigating Maraldi's statements and Lord Brougham's assertions regarding the mathematical exactness of the cells of the bee, Prof. Wyman, by a series of remarkably ingenious measurements, taking plastic casts and natural imprints of the combs, found a surprising amount of variation in the thickness of the different walls, so that he doubted if a typical or mathematically exact cell is ever made. His method of research as compared with that of his prede-

*Compare also Dr. H. P. Bowditch's studies on this subject in the Boston Medical and Surgical Journal, August 10, 1876.

cessors enabled him to utter with authority the dictum that "the isolated study of anything in natural history is a fruitful source of error." In concluding this classical essay he remarks:

"In view of the fact, too, that in meeting a given emergency they do not always adopt the same method, one is driven to the conclusion that the instinct of one and the same species either is not uniform in its action and is quite adaptive in its quality, or to admit, with Réaumur, that bees work with a certain degree of intelligence."

Among the more delicate and difficult researches which he made were his experiments on spontaneous generation. In 1862 he published his "Experiments on the formation of infusoria in boiled solutions of organic matter enclosed in hermetically-sealed vessels and supplied with pure air." The results of these experiments are, in his own words, "that the boiled solutions of organic matter made use of exposed only to air which has passed through tubes heated to redness or enclosed with air in hermetically-sealed vessels and exposed to boiling water became the seat of infusorial life." Wyman then, in his usual judicial manner, gives the conclusions that would probably be drawn by those in favor of and those opposed to the doctrine of spontaneous generation, and leaves the matter quite undecided in the reader's as probably in the author's mind. The subject, however, was not allowed to rest here. Five years after appeared his "Observations and Experiments on Living Organisms in Heated Water." The conclusions he arrived at we will not pause here to recount more than to say that he showed that no life appeared in water boiled beyond a period of five hours.

In print Prof. Wyman refrained from expressing any ultimate opinion relative to the general question of spontaneous generation. To the writer he once remarked that spontaneous generation probably did not occur at the present day, though the first organism might have arisen in this manner; but, he added, "even if we had been on the spot when it occurred we might not have discovered it."

But naturally, from the nature of the subject, the most complex and difficult field of inquiry of the present day is the science of anthropology in its widest sense. This embraces not only the early sciences of archæology and ethnology, but the developmental history of man, and not his physical history only, for the border land

of anthropology merges into the domain of psychology and mythology and the comparative study of religions. In the broadest sense the new science treats of man not only in his physical but in his intellectual, moral, and religious relations.

At the time of his death Wyman was indisputably the leading anthropologist of America, though he had published nothing upon myths, languages, and little on the social relations of the human races. But to the physical history of mankind, particularly of the American aborigines, he has made important contributions, and for this he was well qualified by his early studies in human osteology and comparative craniology, also by his studies in comparative anatomy and physiology. Many have the leisure and disposition to collect Indian relics, to take down the myths and traditions of the red man, to unearth the contents of mounds, and to measure skulls, but Wyman's wide experience, care, cautiousness, self-restraint in dealing with problems over which so many have gone astray—these qualities, together with his ingenuity, good judgment, exact and philosophic cast of mind, have placed him by universal consent among the leading anthropologists of his time.

His early studies in human osteology and that of the higher apes, dating from 1843, paved the way to his later successes. In 1855 he published the results of his measurements of four East Indian crania; in 1862 and 1863 he gave to the public the results of his dissection of a Hottentot; two years later he described the distorted skull of a child from the Hawaiian Islands; in 1868 he published his valuable "Observations on Crania." In this series of papers he begins with suggestions as to the different methods of measuring crania, in the course of which he remarks:

"Brain, not cranial measurement, is, of course, the object of the study of the capacity of the skull; but until some definite results are obtained which will enable the observer to make accurate corrections, we must remain content with cranial measurement for the present, and apply the corrections hereafter." This section is followed by remarks on the relative position of the foramen magnum; the description of crania from the Island of Kauai; the crania of Tsuktshi obtained from the Asiatic side of Behrings Straits; on synostotic crania, and finally he remarks on the Neanderthal skull. To whatever subject he touched upon in anthropology, as in other sciences, he added something new and noteworthy.

In 1864 he published the results of his first examination of In-

dian mounds on the Atlantic coast. A number of minor papers succeeded this first notice. His six reports on the condition of the Peabody Museum of American Archæology and Ethnology contain much that is new and valuable. His most elaborate essay forms the fourth of the memoirs of the Peabody Academy of Science, at Salem, Mass. This was devoted to a special topic, the fresh-water shell heaps of Eastern Florida; but the breadth of treatment, the learning, ingenuity, skill, and literary style of the memoir render it a model. We quote the general conclusions:

1. The shell heaps are the work of man.

2. They are composed of the bones and shells used as food.

3. They contain fire-places and various tools and implements made of stone, bone, or shell; the stone implements are of great rarity in the mounds proper, though not unfrequent on the surface; the former are exceedingly rude; the latter are skillfully wrought as well as more abundant, and are believed to have been introduced by Indians migrating from the north, and are not, therefore, the work of the builders.

4. Fragments of pottery exist in the later but not in the oldest mounds. The pottery was in all cases of a rude kind.

5. The mounds contain human bones, broken up in the same manner as the bones of edible animals, and are believed to be the remains of cannibal feasts.

6. They contain fragments of the bones and teeth of extinct animals, as the mastodon, elephant, horse, ox, turtles, manatee, and a cetacean. These have undergone changes, which show that they were not contemporaneous with the builders of the mounds.

7. The mounds have undergone more or less destructive changes by the action of the river, and in some cases have been separated from the river by the shifting of the channel, in consequence of which swamps have been formed between the mound and the receding shore.

8. Though the absolute age of the mounds cannot be determined a minimum age of several hundred years has been approximately ascertained, justifying the conclusion that some of them were essentially two or three centuries before the arrival of the white man, as shown by the age of the trees growing upon them. Other but not

exact signs of age are to be found in the changes of the channel since the mounds were built, the greater or less destruction of the mounds by the river, the growth of swamps, and the consolidation of the shells through the agency of percolated water charged with lime.

9. Only a single skull of the builders has been found; this differs from some of the burial mounds in being longer, with the ridges and processes more pronounced. There are bones from other parts of the body, from two individuals, in both of which there was the flattening of the tibia. A second collection of human bones was found embedded in sandstone, under a shell heap, at Rock Island, Lake Monroe; only a part of the skull was found; the tibiæ were flattened, but no other peculiarities were observed.

10. Whether the builders of the mounds were the same people as those found there by the Spaniards and the French is uncertain. The absence of pipes in all and of pottery in some of the mounds, and the extreme rarity of ornaments, are consistent with the conclusion that they were a different people. To these may be added the negative fact that no indications have been found that they practiced agriculture.

This memoir was published in December, 1875, a little more than a year after his death. Although the subject seems a limited one—it was discussed in so full and comparative a way; so much relating to general American archæology was comprised in it—it so far excelled any other American work of the same nature that in his death it was at once realized what a loss American anthropology had sustained.

Prof. Wyman left no bulky printed works behind him. The results of long, unwearied investigations were usually condensed into a page or two, the original manuscript, of which it was the abstract, remaining unpublished. His papers and memoirs already published will be classics—models of the best and most ingenious modes of research. Had his health been more robust he would probably have been a more prolific writer, but not a more careful and painstaking investigator. His style was clear, forcible, elegant, and he was impartial in the exposition of the facts he had to communicate.

It remains to learn how Wyman thought on those ultimate problems which have confronted the physiologist and thoughtful naturalist from the days of Democritus down to the time of Lamarck and

Darwin. We have seen that he approached the question of biogenesis or spontaneous generation with a mind free from bias, bigotry, and untrammeled by public opinion. He desired to know the whole truth, or, if that were unattainable, what was the probable truth.

He seemed rather inclined to the belief that in the beginning what we understand as spontaneous generation took place, but that it does not occur at the present time.

He did not believe in a "vital force"—that it was an entity. He distinctly disavowed to the writer his belief in the popular conceptions as to what is usually denominated by that phrase. At the same time he did not give his views in detail as to what he regarded to be the nature of life. He by no means took a purely monistic view of the matter.

As regards the theory of descent, we well remember in 1861 and 1862, while a student attending his lectures, the impartial way in which he would refer to the subject. He then taught that creation went on in one of two modes, either by a series of progressive acts of creation or by a continuous process of evolution. We suppose that Wyman had lectured on the subject in the same judicial, unbiased way for years previous.

At that time the public had begun to take a lively interest in the theory of evolution. But the same calm, dispassionate mode of treatment which the subject received in his public lectures probably characterized his own thoughts on the subject. A few years later, before 1870, in conversations with Professor Wyman it was evident that his mind had fully accepted the doctrine of evolution, and that no other view appeared to him philosophically probable. He did not wait until these views became popular. In his posthumous work on the Florida shell heaps, which must have been written in 1873 or early in 1874, he thus expressed his views:

"The steady progress of discovery justifies the inference that man, in the earliest periods of his existence of which we have knowledge, was at the best a savage, enjoying the advantage of a few rude inventions. According to the theory of evolution, which has the merit of being based upon and not being inconsistent with observed analogies and processes of nature, he must have gone through a period when he was passing out of the animal into the human state, when he was not yet provided with tools of any sort, and when he lived simply the life of a brute." (P. 45.)

As a man he was genial, unassuming, though independent. He

never had a controversy—never lost the friendship or respect of any one; he was not a partisan; he was strangely free from bigotry; he was conspicuously modest. We had almost said that it were better if he had had a little more self-assertion, but his character was so well balanced that we could not have changed the features of his symmetrical nature a hair's breadth.

It would have seemed possible to one who for many years had been a pronounced evolutionist (though not in print), and a disbeliever in the so-called "vital" force as distinguished from the chemico-physical forces, who had dealt so largely in speculative questions of science, who had thought so freely on all points in general and philosophic anthropology, that he would have been skeptical, or indifferent, to the prevailing religious views of his day. So far from this he was an habitual attendant on public worship. Wyman was a Christian philosopher. His well-balanced, comprehensive mind, so absorbed in the study of material things, also acknowledged the Infinite Force operating in and through matter. His nature had too much equipoise, his religious aspirations too much cultivation and strength, to allow him either to fall into an indifferent, negative nescience, an aggressive, self-asserting materialism, or a nerveless, protoplasmic pantheism.

Such, in all its varied, many-sided aspects, was the life-work of this sincere lover of nature, whose whole mind was given to seeking the causes of things. He unreservedly gave his intellectual force to the study of living things. Whatever was endowed with life—that elusive principle or energy animating and pervading matter—attracted his quick glance and serious thought.

We may paraphrase the Latin sentence, and put in his lips, omitting what might be the first clause: "*Vivi nihil a me alienum puto.*"

Never more forcibly than now press upon the mind of the inquiring naturalist those ultimate questions: What is life, and what its origin? The solution of these questions, of such vast moment to the philosophic student of biological science, would seem to be in the lines of inquiry which Wyman pursued with such eagerness and success as his strength would allow. He realized to the full that joy and exultation of soul which comes from the discovery of natural truth, which every true naturalist feels. "I think," he once said to a friend,* "that the most happy and heart-filling thing

* Dr. S. Weir Mitchell. See Lippincott's Magazine, March, 1875.

in the world is to come face to face with something which no one but God ever saw before." He ranks in the advance guard of those students of living nature who have so exalted and widened the scope of the circle of those sciences which have to do with organic nature.

If in considering the character and attainments of the subject of this imperfect notice we have seemed too eulogistic, we can but plead the example of far abler judges of human nature, his own contemporaries, who knew him better than most others, and whose language may seem exaggerated to those who never personally knew our departed associate.

His friend, Dr. S. Weir Mitchell, in the pages from which we have already quoted, thus testifies to the charm of the almost ideal life we have so inadequately sketched:

"I had three or four sets of associations with Wyman, no one of which fails to come back to my remembrance filled with the charm of a man whose whole nature was simple, wholesome, pure, and generous. Others have said all that need be said of what he did for his much-loved science. It is less easy to convey to those who knew him not an impression of the influence he exerted upon younger workers and a sense of the social pleasure which came of his remarkable combination of vast knowledge and general culture, combined with a certain loveliness of character and an almost childlike simplicity. I once heard our greatest preacher nobly illustrate, with Sampson's riddle as his text, the delightfulness of that form of human character in which sweetness and strength are blended. As I listened somehow I began to recall Wyman, for it was just here that his social charm resided. He was intellectually stronger even than any of his contemplated work showed, but he was also the most lovable of men. His mind was very active and remarkably suggestive—so much so that in social chat, even the most careless, he was constantly saying things which made you think or left you thoughtful. For many years he wrote to me frequently, and his letters are filled with the most lucid and happy suggestions, explanations, and comments. After the failure on the part of one of his friends to attain a deserved object of just ambition he wrote to me to state his own extreme regret, and this not once but thrice, as if he was haunted by the sorrow of another's disappointment. At times he was full of the most boyish spirit of jesting, as when in 1862 he wrote me grieving over the secession of Virginia, because we

had both of us lost our easiest supply of rattlesnakes. Then he rejoiced over the fact that we still had the bull-frog, and in another note regrets that the rattlesnakes had not been allowed to vote on the question of seceding."

Dr. Holmes has drawn his portrait in the following words:

"Jeffries Wyman looked his character so well that he might have been known for what he was in a crowd of men of letters and science. Of moderate stature, of slight frame, evidently attenuated by long invalidism, with a well-shaped head, a forehead high rather than broad, his face thin, his features bold, his expression mild, tranquil, intelligent, firm, as of one self-poised, not self-asserting, his scholarly look emphasized by the gold-bowed spectacles his near-sightedness forced him commonly to wear—the picture of himself he has left indelibly impressed on the memory of his friends and pupils is one which it will always be a happiness to recall."

And of his inward graces the following sketch:

"Who has ever preached such a sermon as this sweet and lovely life has been always setting forth in the golden letters of daily action? * * * His characteristic excellencies recall many points of the apostle's description of the virtue which never faileth. He suffered long and was kind; he envied not; he vaunted not himself; he was not puffed up; he sought not his own; was not easily provoked; thought no evil, and rejoiced in the truth. If he differed from Charity in not believing all things, he followed the apostolic precept of trying all things and holding fast that which had stood the trial. Many scientific men of great note have had too obvious failings. Hunter was ill-tempered; Davy was ill-mannered; Wollaston was acquisitive. It is with men like Faraday and Edward Forbes that we would name Jeffries Wyman—Faraday, living in uncomplaining poverty, happy in the incessant pursuit of knowledge, absorbed and earnest as a child over his toys in performing his wonderful experiments at the Royal Institution, simple-hearted, devout in his adhesion to his singular and self-denying creed; Edward Forbes, as shown in Dr. John Brown's eloquent pages, 'the delightful man, the gifted teacher, the consummate naturalist,' 'a child of nature, who lived in her presence and observance,' to whom all were welcome, and who was welcomed by all, 'who won all hearts' by his gifts and 'his unspeakable good nature,' who lived for science, and, when his summons came, 'behaved at the close, with his old composure, considerateness, and sweetness of nature.'"

And then adds a benediction, to which every one who ever knew our associate will from the soul assent:

"The work of his busy hands is done; the sound of his cheerful voice is heard no more; his smile will never welcome us again at the threshold of his beautiful museum; the benediction of his presence will no more hallow our friendly meetings. It is a pleasure of the purest nature, and not easily to be forgotten, to associate one's name but for an hour with such a fragrant memory. It may seem as if too much had been made of his virtues and graces; but all that has been said is no more than all that knew him are saying, and less, how much less! than such a life is entitled to claim. To other hands which will fill out this imperfect outline and add color to these scarcely-tinted features, which will show his intellect in its full proportions, his labors in their entire extent, his thoughts in their complete expression, his character in its noble sincerity, the sweet remembrance of Jeffries Wyman is lovingly commended."*

To Jeffries Wyman.

The wisest man could ask no more of fate
Than to be simple, modest, manly, true,
Safe from the many, honored by the few;
Nothing to count in world, or church, or state,
But inwardly in secret to be great;
To feel mysterious nature ever new,
To touch, if not to grasp, her endless clew,
And learn by each discovery how to wait,
To widen knowledge and escape the praise;
Wisely to teach because more wise to learn;
To toil for science, not to draw men's gaze,
But for her love of self-denial stern;
That such a man could spring from our decays
Fans the soul's nobler faith until it burns.

JAMES RUSSELL LOWELL.

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*Atlantic Monthly, November, 1874.

LIST OF SCIENTIFIC PAPERS AND WORKS

By JEFFRIES WYMAN.*

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1. On the indistinctness of images formed by oblique vision. Boston Medical and Surgical Journal. Sept., 1837.

2. On fossil bones from Georgia and Burmah and a recent elephant's tooth from Singapore. Amer. Journ. Sci., xxxvi, 1839, pp. 385-386.

3. Note on a collection of fossil bones from Athens. Amer. Journ. Sci., July, 1839; Proc. Bost. Soc. Nat. Hist., 1839.

4. Remarks on the worms in measly pork. Amer. Journ. Sci., July, 1839; Proc. Bost. Soc. Nat. Hist., 1839.

5. Remarks on a bat, *Molossus ater*, etc., from Surinam. Amer. Journ. Sci., July, 1839. Proc. Bost. Soc. Nat. Hist., 1839.

6. Notice of the tooth of a mastodon. Amer. Journ. Sci., xxxix, 1840, pp. 53–54.

7. On the anatomy of *Tebennophorus carolinensis*. Boston Proc. Nat. Hist. Soc., i, 1841–44, pp. 154–155; Boston, Journ. Nat. Hist., iv, 1843–44, pp. 410–415.

8. On the anatomy of *Otion cuvieri Leach*. Proc. Bost. Soc. Nat. Hist. [1840.] Amer. Journ. Sci., xxxix, p. 182. June, 1840.

9. On a species of Filaria in the lungs of a sheep. Proc. Bost. Soc. Nat. Hist. [1840.] Amer. Journ. Sci., xxxix, p. 183. Oct., 1840.

10. Report on *Nautilus umbilicatus*. Proc. Bost. Soc. Nat. Hist. [Feb. 19, 1840.] Amer. Jour. Sci., xxxix, p. 185. Oct., 1840.

11. On buried wood, Unio, etc., in river sand at Lowell. Proc. Bost. Soc. Nat. Hist. [July 15, 1840.] Amer. Journ. Sci., xl, p. 388. March, 1841.

12. Note on the cranium of a seal (*Stenorhynchus leptonyx*) from the South Pacific. Proc. Bost. Soc. Nat Hist. [Jan. 20, 1841.] Amer. Journ. Sci., xl, p. 390. March, 1841.

13. Notice of the howling monkey (Simia seniculus). Amer. Journ. Sci., xl, 1841, pp. 387–388.

14. On the anal pouches of the skunk (*Mephitis Americana*). Boston, Proc. Nat. Hist. Soc., i, 1841–44, p. 110.

15. On the sternum of a male trumpeter swan (*Cygnus buccinator*). Boston, Proc. Nat. Hist. Soc., i, 1841–44, p. 119.

16. On the microscopic structure of the teeth of the Lepidosteus and their analogies with those of the labyrinthodonts (with a plate). Boston, Proc.

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*This list has been compiled from the Royal Society's list and that published by Prof. F. W. Putnam, with additions.

Nat. Hist. Soc., i, 1841–44, pp. 131–132; Amer. Journ. Sci., xlv, 1843, pp. 359–363; London Physiol. Journ., 1843–44 (?).

17. Review of Vogt's Embryologie des Salmones. Amer. Journ. Sci., xlv, pp. 211–214. June, 1843.

18. Notice of the Zoölogy of New York. By J. E. DeKay. Amer. Journ. Sci., xlv, pp. 397–399. Sept., 1843.

19. Notice of Agassiz's Monographies and Echinodermes vivans et fossiles. Amer. Journ. Sci., xlv, pp. 399–400. Sept., 1843.

20. On the anatomical structure of *Glandina truncata*, Say. Boston, Proc. Nat. Hist. Soc., i, 1841–44, pp. 154–155; Boston Journ. Nat. Hist., iv, 1843–44, pp. 416–421.

21. Description of a blind fish from a cave in Kentucky. Amer. Journ. Sci., xlv, 1843, pp. 94–96.

22. (With Thomas S. Savage.) Observations on the external characters, habits, and organization of the *Troglodytes niger*, Geof. Boston Journ. Nat. Hist., iv, 1843–44, pp. 362–376, 377–386.

23. On *Echinorhynchus nodosus*. Proc. Bost. Soc. Nat. Hist. Jan. 4, 1843.

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25. Linguatula from a boa. Proc. Bost. Soc. Nat. Hist. March 1, 1843.

26. Ascarides from Cyclopterus. March 1, 1843.

27. Description of a new species of torpedo. Proc. Amer. Acad. Arts and Sci. April 25, 1843.

28. Annual address as president of the Boston Society of Natural History. May 17, 1843.

29. On *Spongia fluviatilis*. Proc. Bost. Soc. Nat. Hist. Sept. 4. 1844.

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32. *Linguatula armillata* and *L. clavata*. Boston, Proc. Nat. Hist. Soc., ii, 1845–48, p. 59; Boston, Journ. Nat. Hist., v, 1845, pp. 255–296.

33. On the fossil skeleton recently exhibited in New York as that of a sea-serpent under the name of Hydrarchos Sillimani. Boston, Proc. Nat. Hist. Soc., ii, 1845–48, pp. 65–68.

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42. On the jet from the blow-holes of whales. Boston, Proc. Nat. Hist. Soc., iii, 1848–51, p. 228.

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55. On the anatomy of *Carcharias obscurus*. Boston, Proc. Nat. Hist. Soc., iii, 1851-54, pp. 123-124.

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79. On a batrachian reptile from the coal formation. Amer. Assoc. Adv. Sci. Proc., 1856 (pt. 2), pp. 172–173.

80. On raindrop marks. Silliman Journ., xxi, 1856, p. 145.

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82. Examination of the Bagre. Proc. Bost. Soc. Nat. Hist. Dec. 16. 1857.

83. Account of some fossil bones collected in Texas. Boston, Proc. Nat. Hist. Soc., vi, 1856–59, pp. 51–54.

84. Description of a cyclopean pig. Boston, Proc. Nat. Hist. Soc., vi, 1856–59, pp. 380–382; also March 18, 1863.

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91. Remarks on the death of Dr. Francis. W. Cragin. Proc. Bost. Soc. Nat. Hist. Sept. 15, 1858.

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94. Account of the collection of gorillas made by Mr. Du Chaillu. Proc. Bost. Soc. Nat. Hist. Jan. 4, 1860.

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97. On the poison apparatus of the rattlesnake. Proc. Bost. Soc. Nat. Hist. May 16, 1860.

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100. On the mode of formation of the rattle of the rattlesnake. Proc. Bost. Soc. Nat. Hist. March 6, 1861.

101. On the presentation to the Society by Dr. William J. Walker of the estate recently occupied by him. Proc. Bost. Soc. Nat. Hist. Aug., 1861.

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104. Dissection of a Hottentot. Proc. Bost. Soc. Nat. Hist. April 2, 1862.

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126. On accommodation of the eye. Proc. Bost. Soc. Nat. Hist. Feb. 1, 1865.

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139. Account of some irregularities noticeable in the cells of the hive-bee. [1865.] Proc. Bost Soc. Nat. Hist., 1866, pp. 234–235.

140. Observations and experiments on living organisms in heated water. Amer. Journ. Sci. xliv, 1867, pp. 152–169.

141. Measurements of some human crania. Proc. Bost. Soc. Nat. Hist. Nov. 20, 1867.

142. Examination of the animals of the New England shell heaps. Proc. Bost. Soc. Nat. Hist. Dec. 4, 1867.

143. Account of the shell mounds of Florida. Proc. Bost. Soc. Nat. Hist. April 17, 1867.

144. Account of the life and scientific career of Dr. A. A. Gould. Proc. Bost. Soc. Nat. Hist. May 1, 1867.

145. Description of the shell heaps at Salisbury, Mass. Proc. Bost. Soc. Nat. Hist. May 15, 1867.

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158. On the fresh-water shell heaps of the St. John's river, East Florida. American Naturalist, ii, 1869, pp. 393–403, 449–463.

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MEMOIR

OF

JARED POTTER KIRTLAND.

1793-1877.

BY

J. S. NEWBERRY.

Read before the National Academy, April 18, 1879.

BIOGRAPHICAL SKETCH OF J. P. KIRTLAND.

"Jared Potter Kirtland, born November 10th, 1793, died December 10th, 1877," is the inscription on the monument which marks the resting place of another of the venerable members of the Academy, whose loss we have recently been called upon to deplore. Between these widely separated dates was lived one of the happiest and most useful lives which has ever fallen to the lot of mortals. The full history of this life must forever remain unwritten, but it becomes my pleasant duty to place on record some of its characteristics and achievements in order that those who in future years shall trace the origin and progress of science in our country shall give due honor to one who was among the most influential of its promoters.

The chief events in the life of Professor Kirtland are briefly as follows:

He was born in Wallingford, Conn., the son of Turhand and Mary Potter Kirtland, and grandson of Dr. Jared Potter, a distinguished physician of Wallingford.

In his childhood he was adopted by his grandfather, becoming a member of his family, and from him his mind received its first guidance toward the studies which he afterward prosecuted. His father was a large stockholder in the Connecticut Land Company, an organization which purchased a considerable portion of the lands held by the State of Connecticut in what was known as the Western Reserve, and in 1797 he was appointed its general agent. In 1803 he removed to Poland, Mahoning County, Ohio, taking with him all his family except Jared, who remained with his grandfather.

From 1807 to 1810 the subject of this memoir pursued a course of study in the Wallingford and Cheshire academies, where he made good progress in the classics and mathematics, and gave proof in all things of a mind of high order. While yet a boy his scientific tastes developed themselves, and he was an indefatigable and acute observer of nature. He also had thus early become an expert in

the cultivation of fruits and flowers, for which his talents had ample scope in the extensive orchards and beautiful garden of Dr. Potter. Of his own choice he now took up the systematic study of botany, and made his first essay in the production of new varities of fruit, by which he afterward became a public benefactor. With the co-operation of his cousins he managed an extensive plantation of white mulberry trees for the rearing of silk-worms; and he there discovered that the female silk-moth secluded from the male could lay fertile eggs, and thus anticipated by half a century the experiments of Siebold and Steenstrup, which resulted in the demonstration of partheno-genesis in insects.

In 1810 Dr. Kirtland was called to Ohio by the state of his father's health, and made the journey on horseback in company with Joshua Stow, of Middletown, Conn. At Lowville, N. Y., they were joined by Alfred Kelly, who subsequently played so important a part in the history of Ohio, then on his way to Cleveland. The journey was full of interest to the young naturalist, and the enthusiasm excited by the thousand objects which attracted his active observation and the acute and original suggestions which they called out were an unceasing source of surprise and enjoyment to his fellow travelers. At Buffalo he had his first introduction to the fish fauna of the lakes, of which all the species were then new to him and many new to science. Not content with acquiring familiarity with their external characteristics, he devoted himself to their careful dissection, and there laid the ground work of his monograph of the fresh-water fishes of the west, published long afterward. At Painesville, Ohio, the party met General Simon Perkins, one of the pioneers in the settlement of the Western Reserve, and already a man of wealth and high consideration. With him young Kirtland went to Warren, and from thence, by another day's journey, to Poland. Here he remained for a year teaching school, and enthusiastically pursuing the study of the new fauna and flora which he found spread out before him. In his father's apiary he took especial interest, and then began a course of observation and experiment upon the culture of bees, which he pursued with undiminished interest for sixty-five years, early becoming a leading authority in the theory and an important contributor to the practice of this useful industry.

In 1811 his grandfather, Dr. Potter, died, bequeathing to him his medical library and a sum of money sufficient to permit him to

attend medical lectures at Edingburgh, Scotland. Returning to Wallingford in order to enter upon the career thus opened to him, he began the study of medicine in the office of Dr. John Andrews, and continued it later in that of Dr. Sylvester Wells, of Hartford.

While pursuing his medical studies he gave much attention to chemistry, for which he was afforded special facilities by Professor Silliman, who, like all who came in contact with him, felt the influence of his personal magnetism, and gladly did what he could to satisfy his insatiable thirst for knowledge.

In 1813 young Kirtland was prepared to enter the medical school of Edingburgh, but the war with Great Britain prevented the accomplishment of his grandfather's wish. The Medical Department of Yale College having just then been established, he entered it, and was the first to matriculate in the list of students. While pursuing his medical studies at Yale he received private instruction in botany from Professor Ives, in mineralogy and geology from Professor Silliman, besides making considerable progress in the science of zoölogy.

At the end of a year of study, too unremitting for even his robust constitution, he was compelled for a time to abandon his books. A few months passed in the fields and woods restored his health, however, and he then entered the medical school of the University of Pennsylvania, at Philadelphia. This city was then, as now, famous for its scientific culture, and he found there abundant occupation for his active mind and such gratification of his scientific tastes as led him ever after to remember his stay there with peculiar pleasure.

In 1815 he returned to New Haven, graduated from the medical department of Yale, and then settled down to practice in Wallingford. For two and a half years he pursued his professional labors here, devoting every moment of unoccupied time to the cultivation of the natural sciences. Plants, flowers, fruit trees, medicinal herbs, minerals, birds, fishes, insects, and shells, all received a share of his attention, and his careful observation brought to light new facts in regard to all.

In 1818 Dr. Kirtland made another journey to Ohio, with the intention of establishing himself there. Having made satisfactory arrangements to that end he returned to the East for his family, but was induced to avail himself of what seemed a specially good opening in his profession, and fixed his place of residence at Durham, Conn.

He continued there five years engaged in active medical practice, but also finding time—which he never wasted—to continue the scientific studies he had pursued with such assiduity at Wallingford. In 1823 his wife and one of his two daughters died, and, prostrated by this bereavement, he yielded to his father's persuasions and transferred his residence to Ohio. Although induced by so sad a cause this step was fraught with blessings to himself and thousands of others, for he not only found a wider field, where his life was crowned with fame and fortune, but his rare and special personal gifts and his great scientific acquirements formed a contribution to the rapidly-developing civilization of the West, of which the value cannot be overestimated. Society was then in its most vigorous, progressive, and yet impressionable stage, and in this society the influence of Dr. Kirtland was felt as an inspiration and a guidance, not alone throughout the community that immediately surrounded him, but over counties and States. There is no question that this change was a sacrifice of his personal scientific reputation. Had he remained at the East his studies would have been focused on fewer subjects; he would perhaps have become a specialist and have left behind him an important monograph to individualize and perpetuate his fame among men. Instead of this he became the teacher of thousands—of doctors, and farmers, and florists, and horticulturists, and naturalists; teaching all of them things of which they would have been ignorant but for him—things that made them better doctors, better farmers, better naturalists, and better men. It is a good thing to be an original investigator and to write learned treatises on abstract scientific subjects; but it is a far better thing to inspire a generation of investigators and teachers, many of whom will write monographs, and all will, in virtue of their inspiration, be careful and thoughtful observers of nature, learning her secrets, and using them to beautify and bless their own and others' lives.

With a personal magnetism that was felt by all who approached him, and to almost all was irresistible, Professor Kirtland communicated to others the enthusiasm and zeal with which he was inspired. The man who came to him with a stolid contempt for book-learning and with no sense of the beautiful as distinct from the profitable left him with higher views and nobler impulses. With an art beyond all art, because it was nature, the clod, the miser, the brute were lured out of themselves and brought to see the world

through the eyes of this magician. With some perhaps his influence was temporary, but with most it was lasting, and with all elevating and happifying. Few men came within the sphere of his enthusiasm, witnessed his restless activity, his thirst for and enjoyment of knowledge, his careful economy of time, his insight into the mysteries of nature; who saw him surrounded by the beautiful things which he had created from materials within the reach of all; the flowers blooming for him as for no other, the fruits blending for him their fairest forms and richest flavors, the very *weeds* and *stones* becoming eloquent and poetical at his beck—could ever go away and look at life and nature with the same eyes as before.

In 1828 Dr. Kirtland was elected the representative of Trumbull county in the Ohio Legislature. Here his voice was heard in advocacy of every good cause and in earnest denunciation of all that in his judgment tended to public or private wrong. One of the most important measures of which he secured the adoption was the new penitentiary system—that is, the substitution of active labor, profitable at the same time to the State and to the convict, for the solitary confinement to which the unfortunate inmates of our prisons had before been condemned. After serving three terms in the Legislature Dr. Kirtland returned to his large medical practice in Poland, where he remained till 1837, when he received and accepted the offer of the professorship of theory and practice of medicine in the Ohio Medical College at Cincinnati. This position he filled with honor and usefulness until 1842.

In 1837 Professor Kirtland was also appointed an assistant on the geological survey of Ohio, then organized under the direction of Professor W. W. Mather. His first summer was devoted to the collection of specimens in all the departments of natural history, with the intention of making them the subjects of careful study and full report. The survey was, however, suspended at the end of the second year, and a large part of the material gathered was thus lost to the State and to science; but a report on the zoölogy of Ohio, which had been prepared by Dr. Kirtland, subsequently published in the second annual report of the survey, contained a nearly complete catalogue of the mammals, birds, reptiles, fishes, and mollusks of the State, with notes upon the different species, which embodied in the briefest possible language many of the results of the original observations made by him through previous years. This catalogue was a most precious gift to the large number of young

naturalists who, like myself, were attempting to gain some knowledge of the zoölogy of the West. Without access to books we groped in the dark—gathering, studying, and comparing—so that the local fauna was well known to us long before the names and relations of the species had been learned. The arrest of the geological survey unfortunately put an end to Dr. Kirtland's work in this connection, and thus greatly disappointed those who were hoping for a continued flow of knowledge from this inexhaustible source.

In preparation for a fuller exposition of the zoölogy of the State Dr. Kirtland had collected a large number of species of birds, fishes, reptiles, and mollusks, and had begun their detailed description. The fishes he found to be least known of all the groups, and to them he gave special attention. He had made drawings of most of the species with his own hand, and both descriptions and figures were subsequently published in the journal of the Boston Society of Natural History. He also studied with much care the large number of species of mollusks found in the State, and made a series of observations on their structure and habits. In this investigation he discovered sexual differences in the *naiades*, and showed that the male and female could be distinguished by the forms of the shells as well as by their internal anatomy. The verity of this important contribution to zoölogy was strenuously denied by many conchologists, but is now universally accepted. Dr. Kirtland had long since made himself a skillful taxidermist, and his collection of birds was the finest in the State, the number and beauty of the specimens attesting at the same time his industry and artistic taste. He had also acquired at great expense one of the finest scientific libraries in the West, and there were few books on his shelves with the contents of which he was not fully and accurately acquainted.

In the same year that he joined the geological corps Dr. Kirtland purchased a fruit farm on the lake shore, a little west of Cleveland, and there built a handsome residence, to which he soon after transferred his family and all his scientific treasures.

In the winter of 1841–2 he gave a course of lectures on "Theory and Practice and Physical Diagnosis" in the Willoughby Medical School, and in 1843, having resigned his position at Cincinnati, he became one of the founders of the Cleveland Medical College, in which he occupied the chair of theory and practice till the close of the session of 1864.

From the time when he first took up his residence in Cleveland till his death Dr. Kirtland was a highly honored and influential member of that community. His country home was beautiful, with flowers from every clime, and his gardens and greenhouses were the admiration of all who beheld them. His farm was also stocked with all the improved varieties of fruit, of many of which he was the originator, and was an arboretum, in which a greater variety of exotic and native trees and shrubs was to be found than on any other private grounds in the State. His city residence was the resort of the most cultivated and intellectual people, and he inspired among these an interest in science which led to the formation in 1845 of the Cleveland Academy of Sciences. Dr. Kirtland was its first and only president, as he continued to hold that office until 1865, when he was still more highly honored by the reorganization of the society and the change of its name to that of Kirtland Society of Natural History. To this society he donated his collections, to which reference has already been made.

The peculiar personal magnetism of the man was shown not only in the interest which he inspired in the subjects he taught to his medical classes in Cleveland and Cincinnati, but also in the fascination he exerted upon the youth of both sexes who came within the magic circle that surrounded him. In every medical class there were always some, and often many who became his private pupils, whom, without compensation, he initiated into the mysteries of taxidermy, or taught the elements of botany and zoölogy, so that they went to their homes to become skillful cultivators of the natural sciences, and with acquirements that often added much to their influence and happiness. So in the cities in which he lived, many of the young men were drawn from the usual occupations and interests of youth to join the ranks of scientific workers. Throughout the West there is now a considerable number of those that have deserved distinction as naturalists who were first attracted to scientific pursuits by the charm which Dr. Kirtland threw around such subjects, and by catching the contagion of his enthusiasm. He was everywhere an active and successful propagandist of his scientific faith, and he won followers and devotees from every rank and condition of life. No better illustration of the irresistible fascination he exerted could be given than that furnished by a recent visit which I made him at his home. In showing me his treasures and novelties he called me into one of the several smaller buildings which were attached to his

residence, and here I found a room the walls of which were lined with shelves, and on these thickly set a great number of stuffed birds still wrapped or tied, showing that they were freshly prepared. On my expressing surprise and admiration at his industry, he disclaimed all credit for the work, and told me it had been done by six young ladies who had formed a volunteer class, to whom he had given lessons, and who had walked twice a week from one to two and a half miles during the summer to practice taxidermy under his supervision.

At various times Dr. Kirtland was the recipient of testimonials of appreciation and esteem from the citizens of the State in which he lived and from those of other States and countries. In 1861 the degree of LL. D. was conferred upon him by Willams College. He was a member of many learned societies, once president of the State Medical Society, and an honored member and officer of several organizations of agriculturists and fruit growers. He was the life-long friend and correspondent of Hon. Marshall P. Wilder, who has, since his death, written an eloquent tribute to his memory in recognition of the services he rendered to agricultural science. Another of his eulogists says: "Of the labors of his long life more more than half were performed for the benefit of the public. The farmers of Ohio have special cause to be grateful to him. He sought out the varieties of fruit best adapted to the climate, and when, after tedious experiments, their value had been demonstrated seeds, slips, and young trees were scattered freely and gratuitously over the country. His social qualities are best summed up in the brief truthful statement that, even in his eighty-second year, he was the spirit and embodiment of youth in the society of both the young and the old, and was the idol of both."

The investigations on zoölogy, by which Dr. Kirtland's fame was most widely extended, were his descriptions of the fishes of Ohio, his discoveries of partheno genesis in insects, and of the distinction of sex in the *Unionidæ*, but these constitute among the least of his claims to honor and grateful remembrance. His great work was that of an educator; and here he was not simply an interesting and magnetic lecturer on medicine, agriculture, and natural sciences, but his whole life was passed in acquiring and imparting knowledge in the broad field of the application of scientific truths to every-day life. His efforts were constantly directed toward beautifying and benefiting the world in which he lived. He not only "caused two

blades of grass to grow where one grew before," but, like some beneficent spirit, he made flowers to bloom and fruits to ripen all along his path in life.

Prof. Kirtland wielded a facile pen, and his contributions to the current literature of the many subjects he investigated are numerous and valuable. All were marked by the originality and the learning of the man. He was also a prompt and voluminous correspondent, and his letters will long be preserved by those who have received them, not only for their beautiful chirography, but for the genial and generous spirit which pervades them, the store of information they contain, and their easy, flowing style.

The personal appearance of Dr. Kirtland was consistent with his character. He was above the medium height, robust and massive in frame, and his noble head attracted attention and admiration wherever seen. His manner was animated, impressive, and cordial, and his conversational powers were such as to delight and instruct all for whom they were exerted; and yet, in his eager thirst for knowledge, he made others talk when they would, and drew from them whatever store of fact or fancy they possessed. In many things he resembled the elder Agassiz, and I shall never forget the occasion when I witnessed their first meeting. They were equally enthusiastic, and just then especially interested in fishes, and the eargerness with which they discussed fins and scales and genera and species communicated itself to all the bystanders.

I have now given a brief and, as I feel, very imperfect sketch of Dr. Kirtland's scientific life and character. It is but justice to him to say that this was not all the man. He was an ardent patriot, a generous and public-spirited citizen—one who shared his ample means freely with all whom he thought deserving of his bounty. His private life was spotless, and he was always an earnest advocate and supporter of good enterprises, a foe to ignorance and vice in every form.

During the war, when sixty-nine years of age, he offered his services to the Governor of Ohio, and for several months acted as examining surgeon for recruits at Columbus and Cleveland. The compensation which he received for this service he devoted to the bounty fund and to the Soldiers' Aid Society of Northern Ohio.

And now, with all I have said, I have left to be told the most attractive and delightful feature in Dr. Kirtland's character. This was his universal and unextinguishable cheerfulness, the result of

an enthusiasm in the pursuit of knowlege and an enjoyment of nature which kept him fresh and green and youthful to the very last. Sorrow and bereavement came to him as to all, but these were received with Christian resignation, and they neither soured his feelings nor chilled his interest in men or things. This constituted his greatest charm to others and the most fruitful source of happiness to himself.

Thus, while I can describe Dr. Kirtland as one of the most remarkable men I have ever met, and can characterize his life as one of the most admirable and useful, I can also say that I think it to have been the happiest of which I have any knowledge. Old age with him was stripped of all its traditional painful attributes. Though venerable in years he was always a boy at heart, and never lost that freshness of feeling and keenness of enjoyment which constitute the peculiar and too often ephemeral charm of youth.

Prof. Kirtland was twice married—in 1815 to Miss Caroline Atwater, of Wallingford, Conn.; in 1825 to Miss Hannah F. Toucey, of Newtown, Conn., whom he outlived several years.

His only child that reached maturity, the daughter of his first wife, now Mrs. Charles Pease, was his constant companion till his death. Mr. and Mrs. Pease, with their children and grandchildren, now occupy the homestead.

MEMOIR

OF

SAMUEL STEDMAN HALDEMAN.

1812-1880.

BY

J. P. LESLEY.

Read before the National Academy, Nov. 16, 1881.

BIOGRAPHICAL MEMOIR OF S. S. HALDEMAN.

Samuel Stedman Haldeman was born at Locust Grove, in Lancaster county, Pennsylvania, on the 12th of August, 1812.

In front of the ancestral mansion in which this offspring of a worthy race first saw the light rolls one of the largest and most beautiful of the rivers of the New World—the river Susquehanna; its spreading tree of waters draining forty-five counties of the two greatest States of the Union, pouring southwards into the head of the largest bay of the Atlantic coast; a shallow river, a mile wide, lovely with green isles and rocky riffles in the summer season; a furious torrent in the early spring, submerging its banks and sweeping the accumulated ice-floes of a thousand affluents, with waste of forest and wreck of human habitations, into the sea.

For some miles above his birthplace low hills of rounded limestone and red shale confine the flood and support a back country (to the east and west) of unsurpassed fertility, tilled by the thrifty descendants of an old German immigration.

Twenty miles below Harrisburg, the capital of the State, the river changes its southeast course and flows due east five miles along the base of a range of quartzite cliffs about four hundred feet high; then bends southward and passes through a wide gate in the ridge, with a vertical wall of rock on the eastern, and high and wooded steeps on the western bank.

From the top of these cliffs, under which young Haldeman was destined to pass his life, he could look northward over the Great valley as the settlers proudly named it—the Cumberland valley as it is now known—bounded by the long, straight, sharp-topped North mountain, called, from its lovely tint through the hazy air, der Blauberg, the Blue mountain, but by the Indians the Kittatinny. As far as the eye can reach towards the east and west the horizontal crest line of this verdant rocky wall of the Great valley, about a thousand feet high, bounds the northern horizon, broken

only once, and to its base, to let the noble river issue upon the low country.

Such was the paradise into which our friend and fellow in science was born, and in which he lived as happy an existence as is vouchsafed to mortals for sixty-eight years, never wandering from it except at long intervals and under stress of scientific necessity, to consult his fellow-workers or the books which he could not otherwise obtain, or to gather information at the centres of learning. He never traveled for the love of traveling. I cannot remember a conversation in which he described the scenery, the architecture, or the social pleasures of a journey. He reveled in anecdotes; but every anecdote related to some fact or mistake or law of science. He bore absence from home with the fortitude and patience of an investigator immersed in his researches, but seemed to think of no place in Europe or America as a possible home, merely as a workshop. His only home was by the banks of the great river, under the beetling cliff, with the roar of the iron furnace pervading the air, and the society of his wife and children amply sufficient for his heart. Here he peacefully lived and worked, and here he peacefully died, alone, in the night, on the 10th of September, 1880, without sickness or suffering, as every man of science should die.

The Haldemans are a Swiss family. They emigrated from the Thuner See in the Canton Bern to the banks of the Susquehanna in the early days of the colony. They were hardy, thrifty, hard-working, intelligent people; acquired land, saved money, and were full of enterprise and energy, lovers of freedom, and shrewd politicians.

Jacob Haldeman, Samuel's great-grandfather, when independence of England was declared in 1776, was the member of the Committee of Public Safety from Rapho township.

John B. Haldeman, his grandfather, was elected member of the General Assembly for Lancaster county in 1795.

Frederick Haldimand, his grand-uncle, however, being an English army officer, remained a tory and an exile, but a distinguished one, for he was the first governor-general of Canada.

Henry Haldeman, his father, was born in 1787 and died in 1849—a man of vigorous intellect and a lover of books, a man of business and of consideration in the State.

His mother, Frances Stedman, bore seven sons, and died when Samuel, the eldest, was a lad twelve years old. An accomplished

musician she endowed her boy with that delicacy of ear by means of which he pursued his life-long investigations into the nature of vocal sounds, resulting in the Trevellyan prize essay, which placed its author at the head of that branch of science.

But his eyes were as alert as his ears. No form in nature escaped his notice. He played in the midst of the undescribed curiosities of a new world. He had no teachers of natural history but his own senses. The nearest society of naturalists, the Academy of Philadelphia, eighty miles distant, was born the same year with himself, and published the first number of its proceedings (May, 1817) not until they were both five years old. Say was then describing almost his first "Species of American Fresh-Water and Land Shells not Noticed in the Systems" and "New Species of North American Insects." Nuttall was making his observations on the birds; George Ord on his flowers, and Le Seuer on the fishes one by one. Troost made his first communication on American mineral forms, and Lardner Vanuxem his first analysis, in 1821. In the same year Henry Seybert's first analyses appear in the journal of the Academy. Jessup's Geological notes on eastern New York and Keating's description of Franklinite appeared in 1822, along with Hare's first meteorological speculations and Schweinitz's description of mosses. Harlan published his batrachian dissection in 1823; Charles Bonaparte described his petrels, and Godman his fragment of mastodon, in 1824; Bigsby, the veteran geologist so lately lost to us, made a flying visit to describe a trilobite, and Jacob Green his first communication on a new salamander, in 1825. John P. Wetherill joined the scientific coterie late in 1826, Conrad and Morton in 1827, and Reynell Coates and Dallas Bache in 1829.

Through the zealous fellowship of these men Philadelphia, when it ceased to be the political capital of the Great Republic, continued to be the capital of American science. Their earlier sporadic studies of details in botany, zoölogy, mineralogy, and physics served not only as a preliminary discipline for their minds, as a reconnoisance of the fields to be afterwards more broadly surveyed, as tentative searches for the best avenues of investigation, as a tuning of the grand piano on which each of them in solo, or in duets and trios, were to perform their symphonies of science, but they served also to make these early musicians of the divine harmony of nature known to each other, affiliating them with the orchestras abroad, somewhat better organized already than their own, and prepare for them an

audience, first in collegiate and then in the mercantile world, on both sides of the Atlantic. And this imperfect sketch of one may perhaps be accepted as an indication of the various career of all.

While young Haldeman was a school boy he not only rummaged his father's excellent library of books, but also the library of fields and waters, through which he played, fished, and hunted like and with other boys. He made a collection of fresh-water shells from both banks of the river and its islands. He boiled out and set up the skeletons of rabbits, opossums, muskrats, and field mice. He enlarged his museum by the addition of birds, which an itinerant methodist minister taught him how to stuff. But he had not yet learned the meaning of the words species and genus. It is doubtful whether we know now the real meaning of those words any better than he did then. But he had not even the economical use of them; for in fact very few generic and specific names had then been assigned. Naturalists were scarce; societies of naturalists scarcer. And it is a noteworthy fact that the lover of nature feels no need of names for the living things he loves until he meets a fellow-lover of them, and the two attempt to gossip about their mistress and her doings. Then the genius of language offers its services. Solitary man might utter cries, but could not have spoken speech, and the anchorite must in time lose his vernacular.

But young Haldeman knew the forms and colors and habits of his shells all the same, although they had no Greek and Latin labels.

At fourteen years of age he was sent to a classical school in Harrisburg. Two years sufficed to prepare him for Dickinson College ,in Carlisle. Fortunate in falling under the instruction of a thoroughbred teacher, Dr. John H. Keagy, the scholar did his master honor. An assistant teacher, Mr. J. T. Q. Mittag, still lives to talk with enthusiasm of the boy's precocious knowledge and indefatigable zeal.

But the classics were not to his taste. The past had little charms for this student of nature. What others thought and felt interested him little. History, politics, metaphysics, poetry were unembodied fictions of unobservant repeaters of undemonstrated traditions of the nature that had passed away. All around him bloomed and breathed an infinity of living things, clad in forms and colors of their own, to stimulate his curiosity, inspire his intellect, and delight his ear and eye. These were his natural teachers. Among these he could run and not be weary, sit and meditate, collect,

examine, contrast, compare, classify, and generalize. This was the work to which he was born and in which he had been bred from infancy. The college routine irked him. The college curriculum was an arena of dust and noise. He thirsted not to learn, but to know. He must find it all out freshly for himself and by himself. "I cannot learn from others" he said once and again; "I must see for myself."

Such a spirit is always noble, but such a conviction is now, in 1881, not wise. But in 1830 it was wiser, but yet not altogether wise. Fifty years has made an enormous difference in the situation and surroundings, the pathways and apparatus of youth of genius. Fifty years ago a born naturalist, especially a naturalist born on this side of the Atlantic, could in fact do no otherwise than make it all out for himself, for it had not been as yet made out by any one. Nor would much time be wasted in rediscovery or reinvestigation. In fact the verification of those earlier isolated observations and rude groupings of facts by several independent naturalists is an indespensable preliminary for the beginnings of our sciences. Now, the student who refuses to learn what has already been accomplished, on the plea that real knowledge must not be traditional but original, shows only the arrogant temper of the folly of youth.

Nevertheless Haldeman learned much at college, and especially from one remarkable man who taught there, Henry Darwin Rogers. Happy the youth who placed himself willingly in the sunshine of that keen intellect, that poet, that called teacher of men, eloquent above the common, and ambitious only to attain the highest summits of observation from which the most extensive outlook of things could be seen.

But Haldeman was not to be a great geologist. The bent of his nature was for analytical discrimination, the fine distinction of details, a true perception of each object in and of itself and of its separate members, by which it and each of them maintains a standing personality in spite of all other beings in the universe. His great master could only see the larger groupings of nature, cared little for the parts, and reveled in general laws. The scholar found it impossible to fix his attention upon an entire landscape by reason of his personal sympathy with and fiery curiosity respecting each proper object in it, rock, tree, flower, bird, beast, insect, and the motion of each, and the sound which each one uttered.

Had Haldeman's eye dominated his ear he would have become

an eminent palæontologist; as it was he did become eminent in one branch of zoölogical science, a branch which demands the finest eye in the world—entomology. But his ear being born master of the eye, his destiny declared itself, and he became eminent as a philologist, the highest authority in all questions touching the analysis of the animal and human voice; and in the course of years his immense collection of facts respecting vocal sounds classified itself, and his intellect was strong enough to bear the classification; and so the spirit of generalization seized upon this analyst of details, as it has upon so many others, and made him a large and generous thinker; opened to him the past history of his science, and showed him how to formulate permanent laws for it. Yet to his dying day he preferred analysis to synthesis, and was never happy in a general discussion until he could bring it back to mere description. For Rogers facts were good for nothing but to breed and illustrate laws. For Haldeman laws were tiresome except as a mere running commentary upon the glorious text of facts. All nature to him was like a volume of scripture, every letter of which, while necessary for forming a word, and the words sentences, and the sentences paragraphs, and the paragraphs chapters, and the chapters books—every letter of which was in itself so beautiful, so rich, so perfect a thing that the copying scribe will gladly obey the affectionate requirement of the Mishnah to say a prayer before he writes it, and to wipe his reed and take new ink before he writes the next.

It was precisely this intense affection for the nature in detail, for every single object of sight and hearing, that in the end made of young Haldeman a great man; for greatness does not mean size, but completeness; and perfection is the same as truth. What he loved was not the name of the thing, nor some story about the thing, nor some relationship of the thing to its surroundings and to the observer, nor its possible usefulness, nor its relative beauty, but the thing itself. He loved each thing for itself. Consequently he studied everything under the best auspices for finding out its true form and nature; and this habit, bred in childhood and matured through after life, with singular simplicity and disinterestedness, with an ever-growing love of fact, truth, reality, made Haldeman one of the most trustworthy observers—one of the most accurate naturalists that ever lived. What he saw he saw, what he heard he heard, and what he described was accepted by others as a good statement—as a matter of course. He therefore seldom erred, ex-

cept when his scorn of less conscientious men excited his passionate opposition. Then he was unjust. To the end of his life he refused to learn of others what they desired to teach as their own observations. He never cared to know anything but his own observations. He never quoted anybody. He seemed unable to give entire faith to anything that was told to him, even by those whom he most sincerely loved and respected. At the meetings of the Academy of Natural Sciences, of the American Association for the Advancement of Science, of the National Academy, he was always interested and amused, and listened keenly to papers on physics, as well as on natural history; but his prevailing mental attitude was that of distrust or half faith, or a mere fugitive curiosity; for he had not made those experiments, dissections, analyses, or observations himself; and they were out of his line, unstudied by himself, therefore undemonstrated. They were very curious and interesting; very instructive *if true;* but they might not be true. What he had himself investigated *that* he was quite sure of being true; and in those investigations of his own he was well content to live.

The natural consequence of such a character was that he accomplished in his own way more than most men. His zeal in his own work hedged it about against interferences and interruptions. It ran its unwearied course straight from the beginning to the end. His collection of facts became vast, and his memory placed the whole of it at his command. He wasted none of his mental energy on copying the notes of others, or in redescribing what was already described by competent observers. The new—the new only—was his first, last, and only love. His letters from Europe were short and bare of stories, for, as he said in self-excuse, everything in Europe has been well told; why tell it again?

College life, therefore, was not at all to his liking, and he abandoned it at the end of the second year, when he was eighteen years old, in 1830, and began again to occupy himself at home wholly with his cabinet of minerals, plants, shells, and insects, and his library of scientific and philological books.

But being a minor, and owing his support to his father, business of some kind or other must be attached to his scientific pursuits, if for nothing else than to save appearances, and the family name from the scandal of idleness and unthrift, to which it had never before been exposed. The early German communities of middle Pennsylvania were an intolerant race, who preferred their barns to

their houses, their horses to their children, and stockings to any kind of bank of safety and exchange. To add field to field, until there was no more room for the sportsman, seemed in their eyes the last word of wisdom. As for useless learning let the lame, the blind, and the puny cultivate that land on which no man can thrive. Most of them had come from the land of the Black Forest, the Vosges, and the intermediate plain of the Palatinate. To these had been added deserting Hessians from the British army and peasants from other German regions of misery and ignorance. On a substratum of mediæval superstitions in their mental character lay a superstratum of sterling virtues—industry, temperance, frugality, and a horror of war. The women were notable housewives, pious, industrious, more saving even than the men, great breeders of families, and as jealous of their rights and of the welfare of their offspring as the lioness of her cubs. The hard-headed fathers had hard-fisted sons, in whom the love of the rifle—that first gift of the god of America to all new-comers—became an enthusiasm. The daughters were round-faced, buxom maidens, able to protect themselves from their lovers and subject them when they became husbands. But all alike—fathers, mothers, sons, and daughters—were as ignorant of what we call knowledge as the cattle in their fields. The hard life of the fatherland had become a life of abundance and freedom and jollity in the new world. Irremediable poverty had been exchanged for unlimited opportunities for acquiring wealth. The lord and the bishop, the recruiting officer and the tax-gatherer, had all been left behind, and the peasant-serf had become a land-owner and a nobleman. He looked upon his broad acres with the pride of an unquestioned and absolute mastership, guarded his fences against the least suspicion of trespass, and herded his cattle and stored his crops in a limestone castle built from his own quarry, with a stone colonnade on one side and lofty bank and bridge on the other; and when his grain was ground teamed it to Philadelphia in a high-peaked wagon, like a ship, drawn by seven great horses, on one of which he rode, while his advent was announced by seven chimes of little bells mounted on the hames. A huge trough hung from the back of the wagon, from which as from a manger the cattle fed at noon, and underneath between the wheels swung from chains the platform tray, in which his mastiff lived to guard him and his cortege.

But in his family life he was still the Deutscher Baur. His

house was low, confined, and crowded; his bedroom stifling; his table a pine board in the kitchen, with the spinning-wheel and reel beside it; no book but Luther's Bible and psalm-book and the almanac; no musical instrument of any kind; no picture on the wall; no ornament but a china dog or sheep on the mantelpiece. The family linen was kept in wooden trunks, and the family clothing hung on wooden pegs around the walls of the bedroom. No flower garden claimed a share of the kitchen garden ground; a few holyhocks and sunflowers flaunted in the sunlight; that was all. Few houses were free from vermin, and, except the bread, which tradition taught the women how to bake excellently well, the food was coarse and unvaried or artificially unwholesome. Dyspepsia and rheumatism were the diseases of the country.

As time went on, and the Indians disappeared with the panther, the wolf, the bear, and the elk from the ever-shrinking stretches of forest land, as hamlets grew into villages and villages into towns, German books got printed, and here and there a German newspaper. Children were sent to poor and scattered German schools. The laws of the colony and then of the Commonwealth were printed both in German and in English. German theological seminaries arose to supply the pulpits; German colleges began to cultivate liberal learning; but still the mass of the population talked German in the house, the store and the market, and cared nothing for any knowledge beyond the limits of farming, litigation, and politics. In 1839 I heard arguments from fine young fellows whom I met in the German counties against believing that the earth was round. The opposition of the German population to the common-school law of Pennsylvania was nearly universal. There was a rooted sentiment in all the German counties that learning spoiled men for the duties of life.

If this sentiment prevailed against the old-fashioned learning and the humanities of the then existing schools, history, eloquence, poetry, philosophy, and mathematics beyond the merest arithmetic, the aversion manifested to the newer sciences may be easily imagined. To shoot birds to stuff and mount, and beasts to dissect and articulate; to collect shells along the river bank and rock specimens from the cliffs; to spend hours with a microscope over some minute fragment of a weed leaf, or flower; to draw the invisible tarsi of noxious bugs with patient precision as if they were dollars and cents in a cash account—was, in the eyes of the Pennsylvania Dutsch, to be

a *taugesnit*, a good-for-nothing, a decent sort of vagabond. Public sentiment frowned upon all such misspenditure of human strength and time.

Young Haldeman was one of the winged horses harnessed, therefore, into the Conestoga market-wagon team. His father had purchased land at the mouth of the Chikiswalungo creek, which enters the Susquehanna river just beneath the great wall of quartzite, at entrance to the gap above Columbia. He himself was set to run a saw-mill on this water-power. But business was more irksome to him even than his college life, and he hailed a threatening sky as a friend coming to give him an excuse for remaining in his back office among his books. He learned to love the rain more than the sunshine; and this penchant for rainy days became a fixed affection which he exhibited to the end of his life. As the storms of society made monks feel safe and comfortable in their cells, so the western thunder-storms of summer and the northeast snow-storms of winter relieved young Haldeman both of business responsibility to his father and of the stupid garrulity of neighbors, and permitted him to remain at home with his own soul in that natural world of forms and colors and sounds in which he was prophet, priest, and king.

Thus he spent five years from 1830 to 1835, when at twenty-three years of age he married Miss Mary A. Hough, who was to be a perfect companion to him for a long life and the mother of his four children.

It was in this interval of five years that preparations were made for those Geological State surveys which we now look back upon as the ground-painting of that great canvas on which the middle distance and foreground picture of American sciences has been in a large part finished in. Palæontological and geological papers begin to take precedency of descriptions of species and chemical analyses of single specimens in the Proceedings of the Philadelphia Academy.

Morton's arrangement of a few of Vanuxem's Notes on the Secondary, Tertiary, and Alluvial Formations of the Atlantic Coast had been published in 1828, with his own descriptions of some New Jersey and Delaware fossil shells and others in 1830. Conrad's first considerable paper on the geology and organic remains of a part of the peninsula of Maryland appeared in 1830. His next, upon the Tertiary beds and fossils of the Southern States, was not read until April, 1834.

Henry D. Rogers read to the Academy in the following June his

first description of anthracite coal. He was already a fellow of the London Geological Society, and had been appointed State geologist of New Jersey. The analyses published in his paper were by Alex. Dallas Bache, then professor of chemistry in the University of Pennsylvania. Rogers was a member of the new Geological Society of Pennsylvania, but not an officer, and it is remarkable that not a single paper of his appears in its first volume of transactions for 1834 (published in 1835). But in the transactions of the American Philosophical Society, of which he became a member January 2, 1835, his name is conjoined with that of Wm. B. Rogers in an important paper on the Tertiary geology of Virginia, read on the 5th of May. The continuation of these contributions was delayed until March, 1839. He published nothing over his own name, from a feeling that every statement of a great subject should be as extensive and complete as possible. What he had to say he reserved for his second or general report on the geology of New Jersey, published in 1840.*

Richard C. Taylor pursued an opposite course, and read numerous geological papers on special districts at the meetings of the Geological Society, the first one on April 23, 1834.

Troost, Ducatel, Clemson, Olmstead, Vanuxem, C. T. Jackson and Alger, Conrad and Lea were all at work in 1835 in different States of the Union. Edward Hitchcock had published his report on Massachusetts in 1833. In 1836 the great surveys of New York and Pennsylvania were commenced; Hall, Mather, Emmons, Vanuxem, Conrad in the former, and Henry D. Rogers, with Booth and Frazer for the first year, in the latter.

Haldeman was destined to throw in his lot with this company of ardent explorers. But that was not his first intention, nor was geology his first love. His observations of the living forms of nature had revealed to him a world of sounds which made all nature vocal, speaking to his ear and to his imagination in distinct articulate language, analogous to that of human creatures. Thus he had early entered the halls of the science of philology by quite a different door from that in common use. The crowd of scholars had their entrance in front, by the gate of written literature; he found the postern to it of organic sound. They studied the generation of words and the collocation of vocables; he was inspired to investigate the pronun-

* The first report of progress was published in 1836–'8, 164 pages.

ciation of the elements and the syllabic combinations of language as they actually reproduce themselves millions of times every hour on the lips of tribes and nations of savage and civilized peoples.

Up to the year 1836 he had taken every opportunity to study human vocal sounds in Pennsylvania. He longed to broaden the field of the research and compare the dialectic German-English of his birthplace with the dialects of foreign countries. He proposed therefore to accompany Lynch's expedition to the Dead Sea, where he could study the vocal elements of a totally different branch of the human family, the Semitic. But the funds allowed by the Government for that expedition were too limited, and his application for a place in it was fruitless.

He thought at one time of applying for an Indian agency, whether in connection with that of Simon Cameron of Lancaster, or not, I do not know; but this plan also was in some way frustrated, and the result was that he accepted an appointment of an entirely different character and for several years a career of active exploration as a working field geologist.

In 1836 Henry D. Rogers, having been State geologist of New Jersey one year, being now appointed State geologist of Pennsylvania, and preparing to devote his chief attention to this new field, called upon his quondam pupil, Haldeman, to assist him in continuing the field operations in New Jersey.

In 1837 Booth having accepted the appointment of State geologist of Delaware, and Frazer commencing his career in the University of Pennsylvania, the corps of assistants was reorganized, and Haldeman was transferred to Pennsylvania, his new colleagues being Whelpley, Trego, and McKinley. The letter of appointment and instructions which he received, dated April 12th, 1837, was of a character which seems now especially stringent. He was required "to allot at least six months of each year, counting from the first of May to some early day in November, to active geological research in such parts of the State" as should be from time to time designated; "to discharge during the remainder of each year various duties connected with the survey, namely, to prepare reports on all the examinations made" by him; "to execute those portions of the geological map assigned" to him, "rectifying the topography of the State map in all cases where it was practicable, and making geological sections and drawings illustrative of the features of the regions explored" by him, * * and perform his share "in col-

lating and arranging the specimens of the several cabinets to be constructed." He was given to understand that "the good of the survey" demanded "that whatever" he might "collect, either in the way of specimens or of informations, whether connected with the economical or scientific geology of the State," was "to be regarded as the property of the Commonwealth, and to be delivered to" the State geologist "as the responsible repository of all the materials procured during the survey." To this was added:

"You are especially enjoined not to impart to the public, or to any individuals but the members of the geological corps of the State, any discoveries, facts, or important opinions bearing upon the mineral resources or scientific geology of any tract of country, however small, until the same shall have been reported to and first published in the reports of the State geologist.

"In all cases where information is sought from you I request that the persons seeking it be desired by you to address their queries to the State geologist, who, being responsible for the consequences of publishing or otherwise making known any facts prior to the publication of his reports, should in justice retain the option of holding back or divulging whatever may be brought to light by the researches of the survey."

He was required to prepare his detailed report of each field season by the 1st of January following, "accompanied by a minute geological map and by such drawings and sections as may assist in understanding the descriptions." Specimens were to be referred to by some number "previously affixed to the specimen and to be found in the catalogues."

Besides these annual reports a brief monthly report of progress was to be sent in on the first day of each month of field work, "giving a sketch of the investigations" of the month and statement of progress.

Provision was made for a "sub-assistant," and the letter of appointment concluded with the following impossible condition:

"While it is expected that you will, your duties continuing to be performed in a manner satisfactory to me, remain in the service of the survey until its completion, yet, should powerful reasons induce you to withdraw, you are required to announce your intention at least one year before your resignation."

In the annual report of progress for that year will be found a sketch of the geology of Dauphin and Lancaster counties, substan-

tially prepared by Haldeman at the close of the field season, after his return to the house which his father had built for the young married pair, within a stone's throw of the iron furnace which his brothers managed, at the mouth of Chickes Creek, and under the morning shadow of the great rock. A long portico, screened by tall columns faces the water and commands a magnificent view up the sweep of the river. To the right spreads the open rolling country of the Great Valley; to the left that of York and southern Lancaster. The dam at Columbia makes a fair broad lake of the river, at the edge of which move canal-boats drawn by horses. Above the river bank and in front of the mansion pass to and fro the long trains of the Pennsylvania railway—a home of comfort and peaceful beauty.

Haldeman was an entitled assistant of the State geologist only one year; his name does not appear in the lists of 1838 and following years in the introduction to the final report of 1858. But his connection with the State geologist and the survey was not by any means broken off.

His widow informs me by letter, dated April 11th, 1881, that her husband "was with Professor Rogers from 1837 (see date of letter [of appointment]) to 1842, and five annual reports were prepared by him. He spent a part of each winter in Philadelphia for that purpose and was in the field every summer. I know that he personally surveyed Dauphin and Lancaster counties, but I cannot recall where else, and I can find no letters that would inform me."

From the programme of the field work of 1837, given in the second annual report, it appears that the sectional study of the Susquehanna river was assigned to Haldeman as his first work, and that this broadened afterwards over Dauphin and Lancaster counties.

From the close of his short official geological career in 1837 he resided forty-two years at his home under Chiquis rock, never leaving it willingly or for any very long absence, refusing all purely business engagements and contenting himself with his share of the profits of the iron works, as a silent partner who had the best right to put implicit trust in the capacity and integrity of his two brothers, Edwin and Paris Haldeman. "Here books and cabinets accumulated under his laborious hands, only to be scattered again and give place to others when his insatiable appetite for knowledge led him

into new fields of investigation."* It was not unusual for him to work sixteen hours out of the twenty-four. His correspondence with John L. Le Conte and other scientific friends was continuous, and he made frequent visits, lasting a day or a week, to consult and discuss difficult points with them at Philadelphia. By this means he was not unseldom seen at the meetings of the American Philosophical Society and Academy of Natural Sciences, and usually had some new communication to make, while he was always ready to participate with liveliness and sometimes with vehemence in the debates.

In conversation, whether public or private, he impressed his companions and audience by a certain unflagging fullness and force of intellectual life. He was excessively fond of talking. He would talk to any one—man, woman, or child—as long as they would listen, whether they comprehended what he said or not. He was always so possessed by his subject that the size, quality, and behavior of his audience were matters of no concern to him. An oration or a lecture was rather a soliloquy. He never placed himself in the mental posture or position of an interlocutor, and therefore felt no sympathy for an audience. There was no consecutive arrangement discernible, because, whatever old fact or new idea occurred to him he uttered at once; and by a thousand cross-threads of memory he was forever led astray. His wealth of illustration was that of an immense museum, in which at every step scores of curious objects distract the visitor's attention. In fact, he may be said never to have met his fellow-men except in this museum, and as its creator and curator, knowing every specimen and its history and its relationships. It was impossible for him to teach systematically any minds who were not already on a par with his own—students and men of research, who had similar museums of facts and ideas of their own. His professional lectures were astonishing *tours de force*, and often ludicrously eccentric to common people. The story goes that he published in a programme that his next lecture would be on fish, but the hour passed in philological statements, anecdotes of stupid blunders made by dictionary men, and illustrations of the unpronounceable sounds of savages, without any allusion to fish until he arrived at the last sentence.

On the other hand, his books and memoirs were written with

* Dr. D. G. Brinton's memoir in the Proc. Amer. Phil. Soc. p. 281, 1881.

extraordinary precision, completeness, and good order. But here also the bent of his nature for analytical definition was conspicuous. When a law is stated its proofs and illustrations follow in long series, overwhelming opposition by the multitude of facts. Little is said of other men's opinions, and dialectic confirmation is scarcely thought of. The world is to Haldeman too much a universe of facts to need much logic. His life was spent in collecting facts in sufficient number, that, when arranged, they should speak for themselves and tell their own tale with little help from him. He seemed to be all the time a spectator of his own children's performances at a school exhibition where they were acquitting themselves creditably by reason of their admirable bringing up.

In 1839 Haldeman communicated to the Academy of Natural Sciences at Philadelphia an analysis of marl from New Jersey. (Jour., VIII, p. 150.)

In 1840 Haldeman's Monograph of the Fresh-water Univalve Mollusca of the United States began to appear in print in Philadelphia, with colored 8° plates by Lawson.* On this work, descriptive of the Limniadæ, his early fame as an able naturalist was established at home and abroad. Eight successive 8° numbers appeared in the years from 1840 to 1845, and during this active interval he made journeys in all directions, as far as Tennessee and the Carolinas, searching for shells along the banks of the rivers of the country. Notices of it are to be found in the Revue Zoölogique for 1842, p. 194, and for 1848, p. 117. No. 1. *Clepsina scabra*, &c. Supplement *Planaria gracilis*.

In this appeared his description of *Scolithus linearis*, a new genus and species of fossil plant, the most ancient organic remain in Pennsylvania. Hall's Palæontology of New York, I, p. 2, with figure. This fossil is abundant in the Chiquis rock, but it is as likely to be a worm burrow as anything else, and doubts of its organic character are felt and expressed by other naturalists.

In these tours of observation his eye fell upon a thousand objects of nature—birds, beasts, fish, shells, insects, plants, rocks—which went to swell his collections, and to furnish not only subjects of discussion among his friends, but for papers read in subsequent years at the meetings of the various societies who in rapid succession hastened to enroll him among their members.

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* Two vols. 8°, now very scarce, the last copy selling at auction for $30.

In 1841 Haldeman published in the Proceedings of the Academy of Natural Sciences of Philadelphia descriptions of five species of *Cyclas*, two of *Cypris*, and two fresh-water shells, all new (Proc. I, 53, 54, 78), and made a verbal statement respecting *Unios* (p. 104), a branch of malacology however which Isaac Lea took possession of and developed in a series of memoirs superbly illustrated, which he published at intervals for many years in the Transactions of the American Philosophical Society at Philadelphia, and continued to publish privately at his own expense.

In Silliman's Journal he published two articles "On the habits and characters of the *Melaniana* of Lamarck." (Am. J. Sc., XLI, 21; XLII, 216.)

In the Journal of the Academy (VIII, p. 200) will be found a paper "On five new species of fluviatile shells."

The year 1842 was a busy one. His entymological club was in high activity, specimens and descriptions passing between Chiquis, York, and Baltimore incessantly. Meltzheimer and Zeigler lived in York county and the Reverend Dr. J. G. Morris in Baltimore.

Le Conte made his first visit to Chiquis, at Haldeman's invitation, on his way back from Washington to Philadelphia, and was persuaded to allow his earliest descriptions of species to be submitted to the quartette and published under their auspices in the Proceedings of the Philadelphia Academy. The acquaintance thus formed developed into a close friendship and alliance in scientific labors, Le Conte bringing to it his youthful traditions of his father's learning, Major John Le Conte, and the native genius for accurate observation and precise description of each reacting on that of the other in the happiest manner for many years. But while the younger friend remained faithful to his favorite science and gradually confined his investigations to one branch of it, the Coleoptera, publishing more and more copiously as years went on down to the present year, the elder friend's interests ranged more widely through the animal kingdom, and his active work upon insects declined and ceased in 1858, although the two continued to consult until 1860, after which Haldeman became wholly devoted to his philological speculations.

In 1842 Haldeman published Descriptions of two new Susquehanna river *perches;* three of the river *unios;* a *cyclops;* two new species of *tubifex;* two of *cyclas;* a new *sterelmintha;* two new *entamostraca;* four *hydrachnæ*, and a *daphnia.* (Proc. Acad. N. S., Phil., Vol. I, N. S., pp. 141, 143, 152, 184, 196.)

He proposed this year a rule of nomenclature for avoiding the bestowal of the same generic or specific name to objects belonging to different branches of the animal kingdom. But the effort was unsuccessful, and the new names given by him and by other naturalists following his leading idea have been relegated by Le Conte and Horn to their proper places as mere synonyms. He proposed *Hypodon* for *Diodon*, a genus of Cetacea, &c. His article on Zoölogical Nomenclature appeared in the American Journal of Science in 1844.

The first number of his Zoölogical Contributions, 8°, printed in Philadelphia, appeared this year and was noticed in the Revue Zoölogique (p. 222). It described the new genus *Unionicola* and nine species of *Hydrachnidæ* parasitic upon *Unio*.

He furnished for the American Journal of Science at New Haven a notice of the zoölogical writings of C. S. Rafinesque. (XLII, 280.)

In the fall and winter of this year 1842 (1842–'3) he gave a course of public lectures on zoölogy in the Franklin Institute at Philadelphia, and his introductory lecture was printed in three numbers of the "Public Ledger" newspaper. (Vol. XIII, November 30, December 2 and 5).

In 1843 he published a catalogue of *Carabideous coleoptera* of southeast Pennsylvania and new descriptions of North American Coleoptera. (Proc. Amer. Acad. N. S., Phil., I, p. 269.)

"On the impropriety of using *vulgar names* in zoölogy." (Zoöl. Contributions, Phil., 8 Dec., p. 34.)

"On the arrangement of *insect cabinets* with a view to indicate the geographical position of the species by colored labels." (Zoöl. Contrib. No. 3, pp. 35–40, 1 map.) This idea was applied by Agassiz in arranging the geological cabinet at Neufchâtel.

For Mr. Trego's Geography of Pennsylvania, which appeared this year, Haldeman furnished an outline of the zoölogy of the State. A notice of this appeared in the Revue Zoölogique for 1846, p. 19.

In 1844 he published "Additional Descriptions of North American *Coleoptera*." (Proc. Acad. N. S., II, pp. 23, 53, 89.)

"Seven New Species of *Aphis*." (Proc. Boston Soc. N. H., I, 168, 169.) This seems to have been his first publication in that society, of which he was elected a member Sept. 2, 1840.

The American Association met this year in Boston, and Halde-

man contributed to its Transactions a report entitled "Enumeration of the *fresh-water mollusca* common to Europe and America, with observations on species and on their distribution."

For the History of Lancaster County, which appeared this year, he furnished as an appendix a sketch of the natural history, including the geology of the county.

For the American Journal of Science he furnished the article on zoölogical nomenclature referred to above (XLVI, p. 18), and an account of some electrical phenomena (XLVI, p. 215).

April 19, 1844, he was elected a member of the American Philosophical Society at Philadelphia.

In 1845 he published "Remarks on *Corydalus cornutus*" (Proc. Acad. N. S., II, 182) and other new genera and species of *insects.* (III, 124–128, 149–151, 348.)

In 1846 he published descriptions of *Unio crassus and U. abacoides* and several new genera and species of insects. (Proc. A. N. S., III, 15, 75, 124.)

He furnished a history of *Agrilus ruficolles* and the figure of the bird to Emmons' Journal of Science and Agriculture (pp. 300, 301), and Trans. N. Y. State Agricultural Society (p. 374).

He also delivered an address at Gettysburg on the occasion of the laying of the corner-stone of the Linnæan Hall of Pennsylvania College.

In this same year his mental activity appears in a new light through a communication on the science of vocal language, made to the Linnæan Society connected with the college at Lancaster, and entitled "On the natural order of the articulate sounds of the human voice." (Linn. Record and Journal, 1846, II, p. 172.)

This was supplemented by his communication to the American Philosophical Society "On the phonology of the Wyandot Indians." (Proc. A. P. S., 1846, IV, p. 268.)

And again the following year by another paper at Lancaster "On the nature of diphthongs and the formation of syllables." (Linn. Rec and Jour., 1847, IV, p. 44.)

This subject occupied a great part of his thoughts even at this early date. It became subsequently his sole occupation, to the exclusion of all other trains of ideas. But his methods were always those of a naturalist, and his data were picked up one by one as opportunities for listening to peculiar pronunciations were thrown in his way. He was especially eager to take advantage of the res-

idence of a few remnants of the Indian tribes in the Eastern and Southern States. He visited Washington when Indian delegations arrived at the seat of Government, for the sole purpose of listening to the articulate sounds which red men of various tribes in the West uttered in conversation with each other.

The results of his earlier observations were reported at the Boston meeting of the American Association in 1849 and at a meeting of the American Academy in Boston. His paper was entitled "On some points of linguistic ethnology," with illustrations chiefly from the aboriginal languages of North America. (Proc. A. A. F. A. S., 1849, p. 423; Proc. Am. Acad., Boston, II, 165 to 178; 1850, V. 5.) And those who heard his wonderful mimicry of the extraordinary sounds of the savages will remember the curiosity and amusement they excited and the conviction which the hearers felt in his exceptional ability as an original investigator of this branch of science—a conviction amply justified by the appearance of his Elements of Latin Pronunciation in 1851 and of his Trevyllian Prize Essay in Vol. XI of the Transactions of the American Philosophical Society in 1859.

In 1847, besides his committee Report on the progress of entomology in the United States in 1846, he published more genera and species of *insects;* a description of *Salamandra erythronta*, and corrections of previous papers. (Proc. Acad. N. S., III, 149, 315, 348.)

Materials towards a history of the *Coleoptera longicornia* of the United States constituted a memoir for the transactions of the American Philosophical Society (X. 2 S., pp. 27-66; Proc. A. P. S., IV, p. 371 to 376). Corrections and additions to this paper appear in the Proc. A. P. S., IV, 371 to 376.

In the proceedings of this society (IV, 356) he described the occurrence of a large species of *Filaria* in a species of *Lycosa*. (*F. lycosæ*, Iconog. Encyc., p. 48.)

Descriptions of several new and interesting animals: *Cecidomyia robiniæ*, *Apus affinis*, &c., were published in Emmons' Amer. Jour. S. and Ag., VI, 192, 193, and Proc. Boston S. N. H., VI, 401, 403; also his description of *Æonia ebonina*, a new species of *trilobite* (p. 191.)

"On the occurrence of a species of *Evania* in various parts of the world carried by the *Blatta* which infests ships" was the title of a paper which he read before the American Association for the Advancement of Science, of which he had become a member at its

first meeting in 1848 at Philadelphia. The paper was published in Emmons' Am. Jour., VI, 211.

He furnished a paper also "On the Apparent Projection of a Planet upon the Moon's Disc during an Occultation" for the Proceedings of the American Philosophical Society (vol. V, p. 16).

At the meeting of the American Association this year he read a paper "On the Chromatograph, a Modification of the Chromatic Wheel of Newton." (Proc. 1847.)

In this year, 1847, he made his first voyage to Europe, and wrote in French, in Paris, for Dr. Chenu's Illustrations Conchologiques, a paper entitled Monographie du genre *Leptoxis* of Rafinesque (*anculosa* of Say), with a figure. I have no further information respecting this journey, for he was no diary keeper, and hated the whole tribe of *raconteurs de voyage*, but it must have exercised a noteworthy influence upon his after life. He did not revisit the Old World, as we foolishly call it, until 1859, and then with set purposes of a purely philological kind. Paris now; then Rome. The Jardin des plantes in 1847—the Propaganda dei fidei in 1859. Such is human evolution in the individual, reversing its direction in the race.

In 1848 he published a description of a fibrous lava of Hawaii. (Proc. Acad. N. S., IV, 5.)

Descriptions of North American *Coleoptera*, chiefly in the cabinet of J. L. Le Conte, &c., appeared in the Journal of the Academy, I [2 S], pp. 95–110, and *separata* were printed in Philadelphia, with four plates, in 1849.

"On a new *organ of sound* in *Lepidoptera;*" "On the supposed identity of *Atops trilineatus* with *Triarthrus beckii;*" "On the occurrence of *Cremastocheilus* and other insects in ants' nests, and of *Chelifer* found parasite under the elytra of *Alaus oculatus;*" "On the history and transformations of *Corydalus cornutus*," and "On certain insects common to New Mexico and the United States" are papers which he sent to Silliman's Journal. (IV, V [2 S.], pp. 435, 107, 148, 157, 435.)

At the meeting of the American Association he described a perfect American specimen of the trilobite *Phacops hausmanni*.

"On results of smelting iron with anthracite coal" and "On the construction of furnaces to smelt iron with anthracite" are two of his papers which appeared in the American Journal of Science (V, p. 296, and VI, p. 74, with a figure), of great importance for our

estimate of Haldeman's life and character. They show that the man of science was not a mere naturalist. They intimate his connection with the business world and his curious observation of the events of the passing age. They are an index of one of the great historical events of the century—an event destined to revolutionize the face of society in the New World and to react powerfully on the civilization of Europe. The first trials of anthracite in the Pioneer furnace at Pottsville in the winter and spring of 1839 under the superintendence of William Lyman of Boston, and the brilliant success of John Thomas, the Welshman sent over by the Swede Company to make the same experiment on the Lehigh river, were watched by all the iron men of middle and western Pennsylvania with the liveliest attention. In the end anthracite furnaces took the place of charcoal furnaces in the eastern part of the State, and the Haldemans foresaw and prepared for the new order of things. Before ten years had passed one-half of all the iron made in the United States was Pennsylvania anthracite iron; and the vast increase of the output of metal not only lowered its price and favored the extension of the railway system, but compelled the Kelly's invention of blown iron in Kentucky, from which came directly Bessemer's invention of the low-steel converter, enhancing the average rate of transport and lowering the cost of rails and rolling-stock.

No wonder then that Haldeman was compelled for a moment to leave the shells on the river bank and the bugs on the trees to study the shape of his brothers' furnace-stack, the strength and heat of its blast, and the quality of the pig-metal produced from the burden when mixed with the new fuel; and to add one more illustration of the fact that a well-disciplined man of science can transfer his faculties of observation and generalization to any legitimate new region of inquiry and find himself a practical discoverer there also.

The same connection with the interests of the iron furnace at his door gave him the chance for making the discovery of the *artificial production of capillary lava*, which he described at a meeting of the Academy in Philadelphia (Proc. IV, 5), just as his difficulties in keeping his bugs safe from parasitic destruction had induced him to communicate to the Academy, long before, his observations of facts on the *preservative qualities of copper*. (Proc. I, 269.)

In 1849 he published descriptions of new species of *Cryptocephalinæ* and *Hymenoptera* (Proc. Acad. N. S., IV, 170, 203). Separata were published in Philadelphia. This paper appeared as *Cryptoce-*

phalinorum borealis, &c., in the Journal of the Academy. (I, [N. S.] p. 245 to 265.)

"On the identity of *Anomma* with *Dorylus* . . . . driver ants," appeared in Proc. Acad. N. S., IV, 200-202.

"History of *Phalangopsis*, a genus of Orthoptera, with a description of three new species," and "On the larva of *Physocœlus inflatus*," were read before the second meeting of the American Association in 1849, and published in their transactions. (II, 1850, pp. 346, 347.)

He described several of the Susquehanna river fish species at this meeting (Proc., p. 411), and these appeared in the Journal of the Academy N. S., Philadelphia (vol. VIII, p. 330—).

"On Some Points of Linguistic Ethnology" (a paper already referred to) was read at the Boston meeting of this year.

In 1850 he published his report on the progress of Entomology in the United States during the year 1849, as chairman of the commitee of the Academy. (Proc. V, 5.)

He read a note on the orthopterid genus *Daihinia* at the Boston meeting of the American Association. (II, 346, 347.)

Silliman's Journal published his four new species of *Hemiptera* and two new parasitic *Hymenoptera* (IX, 108-111.)

He wrote for the Iconographic Encyclopedia of Science, Literature, and Arts, published in New York, the articles Articulata; insecta (II, 132-196), Entomology, Conchology, Radiata, and others.

He published this year his Zoölogy of the Invertebrate Animals.

In 1851 he published a description of *Eriophilus mali* (*Hymen*) in the Pennsylvania Farmers' Journal, August, and in the Proc. Boston S. N. H. (VI, 401–403.)

His "Elements of Latin Pronunciation for the use of Students in Language, Law, Medicine, Zoölogy, Botany, &c." Philadelphia, 8°, pp. —, alluded to above, appeared this year, and slowly worked its way into favor with philologists, who recognized the severe natural-history method of inquiry and demonstration followed by the author. However far the subject may seem to lie away from the pursuits of collectors, microscopists, and anatomists, it touches them all closely when they begin to classify and give names to their genera and species; and Haldeman found himself involved in an etymological and archæological labyrinth—becoming, in fact, as so many geologists have become, a palæolinguist; so that this accidental,

outside, mere dress connection of the wordy presentation of the objects of nature grew into a great intellectual vocation for him, calling him at last to abandon all his previous pursuits to devote himself to it, as will be noticed further on.

Much of his time in 1851 and 1852 was spent in editing the Pennsylvania Farmers' Journal, but he continued his entymological researches. The United States Exploring Expedition under Stansbury committed to him the study of its insects, his descriptions of which appear, with two plates, as Appendix C, pp. 366 to 378 of the report. A short account of an Albino *Tamias lysteri* appears in the Proc. A. N. S., Philadelphia, VI, 198.

In 1853 he sent a description of *Aphis stamineus* to the Boston S. N. H. (Proc. VI, 401) and to the Penn. Horticultural Soc., of which he was a member. (Proc., 1853.) He furnished Dr. John L. Le Conte with descriptions of insects, which appear as an appendix to his catalogue in the Proc. A. N. S., Philadelphia (VI, 361–5). But, as if to show that his philology did not sleep, he read at the Cleveland meeting of the A. A. F. A. S. an "Investigation on the power of the Greek *Z* by means of phonetic laws." (Proc., VII, p. 251.)

In 1854 he published remarks on Girard's *Limnadella*, and this was his last communication to the Academy for some years. (Proc. A. N. S., Philadelphia, VII, 34.)

In 1855 was published the second edition of Taylor's Statistics of Coal, under the editorship of Haldeman, who not only saw this large and important volume through the press, but showed what he had been about the previous year or two, during which his communications to the various natural-history societies had almost wholly ceased. In point of fact he had agreed with Mrs. Taylor after the death of her lamented husband, the geologist, Richard Cowling Taylor (in 1851), to assist her in revising and bringing up to date his great work on coal, the first edition of which had appeared in 1848 as a volume of 900 pages, 148 of which were in the Introduction, and 709 made eight chapters on the statistics of coal in the United States, British America, Russian America, Oregon Territory, Upper California, New Mexico, Mexico, and Texas.

The second edition was printed with larger type, 224 pages of Introduction* and only 400 pages of statistical matter, relating

* Pp. 19 to 91 and 112 to 119 being the only additions.

solely to the United States, Oregon, Upper California, Texas, New Mexico, British America, and Russian America.

The coal statistics of Europe, Asia, and Africa noticed in the first edition were omitted in the second; but the American tables are enlarged; and as this was done by reference to reports of the geological surveys of various States and other sources of information the labor was very great. Mrs. Taylor had a portfolio of her husband's unpublished additional notes, and had continued her habit of making selection of such from all available sources; but in spite of the assistance she afforded the editor, his task was a long and tedious one.

In 1856 Haldeman read before the American Association at its meeting in Albany a paper on the "Relations Between Chinese and the Indo-European Languages." (Proc. X, pp. 201-216.) Over this dangerous ground Haldeman travels with comparative security, because of his long previous scientific training in the delicate manipulation of contrasts and resemblances, of false and true analogies and homologies among the innumerable forms of living things. In fact, this memoir is a fine example of how naturally a naturalist, turning aside into the garden of philology, looks upon words as life forms, and distinguishes them as fossil or recent. Many of his tabular cross references are not only most ingenious but really valuable; or will become so after the present taboo of the vocabulary by comparative philologists has—as it must inevitably—come to an end.

In 1857 and 1858 I find no record of his publications. He was busy with his lectures in Dover, Delaware. He had been appointed professor of natural history in the University of Pennsylvania at Philadelphia in 1851. In 1855 he accepted a similar professorship in Delaware College, and subsequently lectured there on his favorite theme as professor of comparative philology, being the first occupant of that new chair, which he held continuously until his death. But while lecturing to his classes in Delaware he acted as professor of geology and chemistry in the State Agricultural College of Pennsylvania.

In 1859 he went a second time to Europe, and took that occasion to read a paper before the French Entymological Society on his "Discovery of an Organ of stridulation in an *Orthosia*." (See Ann. [Ser. 3] VII, p. 43.) I will anticipate by saying here that he sailed a third time for Europe in 1861–'2; a fourth time in 1866, and a fifth in 1875.

"These journeys," writes Mrs. Haldeman to me, "were chiefly undertaken for the study of dialects and languages, in order to verify his theories of the sounds of the human voice."

In England and Germany he was of course at home, for English and German were his vernacular forms of speech, and his native Pennsylvanisch Deutsch gave him the great advantage of comprehending what merely literary travelers find impossible jargons in Swabia and the Palatinate. He became able to converse in French and Italian; and his Latin was a medium of communication with the priesthood of the Catholic church, into communion with which he had been received in 1844. (?)

In London and Paris he came into accidental contact with, or rather diligently sought and cultivated, the acquaintance of people of all nations, even of the antipodes. To cite instances in evidence of the amplitude and variety of such opportunities: He learned from Emma, Queen of the Sandwich Islands, then in London, the sounds of the Hawaiian dialects; those of the Guzerati from a Parsee in Paris; those of the Tonga Islands from natives studying at Rome; Khwrdish he found also spoken by the students of the Propaganda.

He passed a great deal of his time in the British Museum and in the Bibliotèques Nationale and Mazarin, and with men who had been corresponding with him by letter for years—Pitman, Ellis, Latham, Prince Bonaparte, in London; De Chenu, De Menerville, Biot, Humbert, in Paris; De Saussure, at Geneva; Belardi, at Turin; Metzel, in Leipsig. Others, like Bleek, at the Cape of Good Hope, and Lundel, of Stockholm, he did not of course see, but he kept up his correspondence with them.

Having on his first visit to Italy found Rome the best place for the study of the living voice, he revisited it on a subsequent voyage. Special favors were shown to him by the regency of the Propaganda. He described to me on his return his methods of research. He was allowed *carte blanche* to select his specimen-men from the list of students, and these were detailed from their studies successively as he required them. Each in turn remained with him for several days, submitting to that trying and amusing cross-examination which we old friends of Haldeman find it easy to picture to ourselves. No lawyer ever handled a witness with more pitiless persecution until the last drop of knowledge was drained from him and the last shade of uncertainty respecting any statement was dis-

pelled. He exhausted in this way the vocal repertoire of between forty and fifty varieties of human speech during one of these two residences in Rome.

Whatever of this kind was in a man he could elicit by the directness of his method and the indefatigable insistence of his zeal. He worked over a student under examination not at all in the manner of conversation, but as an artist works on a bust in wax. His honest endeavors inspired both confidence in his intentions and interest in his operations. His questions opened up so many unexpected trains of ideas that those who at first were simply bored found themselves takiug a personal part in the investigation, and did their best to analyze the hitherto unconcious play of their own vocal organs. Ou his side the discipline of infinite repetition had its natural results, for he could mimic the most extraordinary clicks and clacks of Pacific coast or South Africa as easily as the hamsa in Arabic, or the combinations familiar to the Indians of the Mexican Gulf.

I have already said that his organs of hearing were extraordinarily perfect, as was early shown by his ability to detect and discriminate the several sounds made by insects. It led to the discovery of a new organ of sound in lepidopterous insects, described by him in Silliman's Journal in 1848.

His papers: On the natural order of the articulate sounds of the human voice, published at Lancaster in 1846; On the nature of diphthongs and the formation of syllables in 1847; On the phonology of the Wyandots in 1846; On some points in linguistic ethnology in 1849; his volume on Latin pronunciation in 1851—have been already noticed under their respective years. They had made his name as an original investigator known and gave him ready access to men of scieuce everywhere. In 1853 Agassiz wrote to him, "I long to see your work on etymology. I have always been delighted with the originalty with which you treat these subjects." To his intellectual ability, when he chose to exercise it in generalizing from his multitudinous data, the highest testimony is given by Charles Darwin in the preface to his "Origin of Species" (p. vii), where he refers to Haldeman's "able paper on species and their distribution."

But a royal stamp was set upon Haldeman's life work in London when he carried off from a competition with eighteen competitors from all parts of Europe the Trevyllian prize for his essay entitled

"Analytic Orthography: An investigation of the sounds of the human voice and their alphabetic notation."

On his return to America he offered the manuscript to the American Philosophical Society in Philadelphia, and it was gladly accepted and published * in the Transactions of the Society and afterwards by J. B. Lippincott & Co., of Philadelphia, in 1860.

An analysis of the features of this remarkable work would be hardly in place in this brief biographical memoir of its author, but the remark may be permitted that its design was as original as its execution was admirably well ordered and complete, and it is safe to say that by this exploration he exhausted the range of vocal possibilities for human beings of all ages and climes.

From 1860 to 1865, the interval of five years between the appearance of his prize essay and the issue of his little volume of "Affixes in their Origin and Application" (E. H. Butler & Co., Philadelphia, 1865), Haldeman was immersed in linguistic studies, mostly at his home on the banks of the Susquehanna. His second voyage to Europe, in 1861–'2, was no interruption to these studies, for he traveled not for pleasure or for health, to gratify the curiosity of a sightseer, or to assuage the *ennui* of a *dilettante*, but as an isolated ear might be imagined to travel on some special business, commissioned by the other organs of the body, and confining its attention faithfully to that and to that alone.

In 1862, at a meeting of the American Philosophical Society, January 3, he described certain peculiar sounds and words of the Basque language, which he had obtained from natives of the Pyrenees during his second journey in Europe; but he made no other communication at the meetings until October 2, 1863, when he followed Prof. Chase's quotations from his prize essay (in answer to Mr. Dubois' questions concerning the number of possible vowel sounds) with some remarks, and giving some illustrations of "whispered vowels."

In 1864 he published his Notes on Wilson's Readers.

At a meeting of the American Philosophical Society in Philadelphia, February 19th, he exhibited a curiously-shaped pebble, excavated from the Susquehannah Valley drift deposits, to illustrate the very artificial aspect which purely natural objects of this kind sometimes wear, and therefore how cautious geologists should be in

* Vol. XI, p. 259. See Proc. A. P. S., Vol. VII, pp. 125, 126.

accepting them as evidences of human handiwork. (Proc. A. P. S., IX, 342.)

In this year also appeared his book entitled "Tours of a Chess Knight," mathematically treated.

In 1866 I have already said he made his fourth visit to Europe for philological studies.

In 1868 he read a lecture before the Teachers' Association of Pennsylvania "On Etymology as a means of Education," and it was published in the Pennsylvania School Journal for October.

He published "Quackery in American Literature" in the January number of the Southern Review; an article on "School Readers" in the April number, and articles on "Northern Geographies" and "American Dictionaries" in the January and July numbers of 1869.

He also published, in 1868, his "Rhymes of the Poets," under the *nom de plume* of Felix Ago. (E. H. Butler & Co., Philadelphia.)

In the American Philological Association, Transactions 1869-70, appears his essay "On the German Vernacular of Pennsylvania," in which he was naturally an adept, having heard it spoken around him all his life. It was a fruitful source of information to him, an inexhaustible mine of investigation in all his researches into the mode, degree, and direction of those verbal and grammatical changes which all languages undergo, especially under circumstances of migration.

In 1870 (May 16), at a meeting of the American Philosophical Society, he exhibited a cylindrical colored bead found in digging the Pennsylvania canal through an Indian grave on the banks of the Susquehanna river, about the year 1832. He referred the members to the figures of similar beads (called Phœnician and Venetian) published in the society's proceedings of December 3, 1862, VIII, p. 114).

He sent to the London Philological Society a paper entitled "Pennsylvania Dutch, a dialect of South German, with an infusion of English." It was read in London June 3, 1870, and afterwards published by the Reformed Publication Board in Philadelphia in 1872.

In 1871 a second edition of his "Affixes to English Words" was published by the Butlers of Philadelphia.

Previous to November 1, 1872, Haldeman had made a very ex-

tensive collection of sonnets for the purpose of studying their construction and discovering some normal rhythmic order. He had tabulated 600 arrangements of the sonnet, and the tale was evidently not yet complete when at a meeting of the American Philosophical Society of that date he described his plan and purpose. (See Proc. A. P. S., XII, p. 561.)

In 1873, before sending a review of Prof. Blain's "Latin Pronunciation" to the Southern Magazine for October, he presented to the American Philological Association a memoir "On the pronunciation of Latin" as presented in several recent grammars," and it was printed in the Transactions of 1873. In private conversation he was accustomed to indulge in the most violent, and at the same time most amusing, invectives against the common run of authors of popular text-books in all departments of science, and his illustrations showed what a curiosity-shop his memory had become.

In 1874 his "Notes on Etymology" appeared in the Pennsylvania School Journal in the number for May, and a paper "On an English vowel mutation present in *cag, keg,*" in the Transactions of the American Philological Association.

In 1875 another paper "On an English consonant mutation present in *proof, prove,*" appears in the Transactions of the same society. He also sent a review of Prof. Shipherd's History of the English Language to the Southern Magazine for January.

This was the year of his fifth and last voyage to Europe, where he was so busy with his researches that he communicated nothing to the societies of which he was a member except a short notice of a polychrome bead from Florida to the Smithsonian Report of 1877.

In 1878 appeared from the press the work on which he had been so assiduously engaged for years—"Outlines of Etymology," published by J. B. Lippincott, of Philadelphia.

Being now set somewhat free he began to make again communications to societies of which he was a member, and read before the American Philological Association of that year (1878) a paper on "Virgil's Hexameters," which was published in their Transactions.

He also sent "Gleanings" of his studies to the American Antiquarian, Vol. I, No. 2.

In 1879 he stated "The etymologic objection to the spelling reform" in so acceptable a form that it was published in the Proceedings of the National Educational Association for that year. (P. 257.) He also wrote a "Review of Prof. Fisher's Three Pro-

nunciations of Latin," which appeared in Stoddart's Review for 1880.

He was now ardently engaged in excavating the floor of a pre-historic cave at the base of Chiquis rock, near his house, which he had always suspected to contain valuable relics of the past, as well as in enlarging his Indian cabinet from the surrounding country. It soon became known through Lancaster, York, Dauphin, and Cumberland counties that he would buy all that was brought to him of any value, and scores of boys became systematic arrow-head hunters. A few months before he died he told me many anecdotes of his adventures with these boys, one of which is worth preserving, not so much for its own sake as because it illustrates the habitual attitude of his mind towards all phenomena. Two boys were searching the furrows of a ploughed field. One of them found an arrow-head, but after examining it threw it away as good for nothing; the other afterwards refound it, approved it, and brought it to Haldeman for sale. Then the first boy claimed it as first discoverer. To Haldeman the personal element in the contest was invisible; but he saw in the adventure an illustration of the philosophy of ownership and a bizarre exhibition of the conflict among men of science over rights of priority. "You see," he said, "to find is not to find; to own is not to own. To know is to find; and to find by knowledge is to own. That is mine, says one. Not if you don't comprehend it, replies the other; you merely picked it up; I found it." And on this philosophical basis he paid the second boy and dismissed the first with an admonition to become a wiser man.

His description of the objects found by him in the Rock Retreat at Chiquis, as he called it, had gone through the press as the last Article in the XVth Volume of the Transactions of the American Philosophical Society; but the fourteen quarto plates on which he had arranged in series typical specimens of his collection were not quite finished. This memoir was his last. But it is not the last of his many writings to be placed on record; for he left in the press of Lippincott & Co., of Philadelphia, a book entitled "Word Building."

In the American Naturalist for May, 1879, he treated the subject of "Unsymmetric arrow-heads and allied forms" with his usual acumen, drawing natural-history conclusions from them.

In 1880, at the meeting of the American Association at Boston, a few days before his death, he described some "Stone axes from British Guiana" sent to him by one of his daughters, the wife of

the United States consul at Pernambuco, who had resided there many years and frequently corresponded with her father on his favorite subjects, both philological and antiquarian. He read also at the same meeting "Remarks on Aboriginal Pottery."

A few days after his return from Boston he wrote to me that he had greatly enjoyed that meeting, which was one of the finest ever held by the Association, but that he was now too old to have such pleasures without paying too high a price for them.

That same night he died. He vanished from the sight and hearing of his friends and correspondents in science and learning as unexpectedly and suddenly as though he had stepped into his Rock Retreat and the great wall of Chiquis cliff had shut upon him like a door.

One more of the world's magicians had performed his wonders on the planet before admiring and loving audiences, made his bow, and gone elsewhere. We miss the magic sorely; we miss the magician more. That is all that we can say. "Everything is well and wisely put." He learned well; he taught well; his scholars are now among our teachers. American science was his cotemporary, classmate, and friend; but while we submit each one in turn to the inevitable law of growth and decay in the flesh, science knows nothing of decay, but only growth; and the human intellect, at the same moment entering and issuing from its coffin, will pursue its course still a cotemporary of the science of the future.*

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* NOTE APRIL, 1886.—Mrs. Haldeman died July, 1883. Haldeman left at his death two sons and two daughters: Carston N. Haldeman, who is unmarried and resides in Tallahassee, Fla. Francis H. Haldeman, married to H. S. Stauffer, manufacturer of Mt. Joy, Lancaster county. Eliza J. Haldeman, who married Col. Philip Figyelmesy, appointed by Mr. Lincoln U. S. Consul at Demerara, and still occupying that post; and Victor M. Haldeman, who married Josephine Kemmerer, and resides at Gen. Wayne, Delaware county, Pa., engaged in business. He left four grandchildren: Loyos H. Figyelmesy, named after Louis Kossuth, under whom his father fought in Hungary; Samuel H. Figyelmesy; Mary Hough Kemmerer, and Gay Kemmerer.

MEMOIR

OF

GOUVERNEUR KEMBLE WARREN.

1830-1882.

BY

HENRY L. ABBOT.

Read before the National Academy, April 17, 1884.

BIOGRAPHICAL MEMOIR OF GOUVERNEUR KEMBLE WARREN.

Mr. President and Gentlemen of the Academy:

The tendency of modern science is so much toward specialties that it is rare in our generation to find men eminent in widely different departments of knowledge. General Warren was an exception to this rule, partly because his public duties at different periods of his life led him to devote attention to very distinct branches of his profession, partly because the character of his mind and his intense activity made him thoroughly investigate whatever happened to form the subject of his studies, and partly because it was his habit when mentally oppressed with overwork to seek relief by reading some favorite scientific or literary treatise to break the current of thought.

His mathematical education at West Point early turned his mind at leisure moments to the broader subject of logic, and his extensive reading in this direction exerted an influence which can be traced everywhere throughout his numerous writings. Close and convincing reasoning and good arrangement of ideas are characteristic of them all.

As a general he applied the same systematic analysis to the ill-defined impulses which control the actions of men in war, and this habit, with other high qualities of mind and heart, left him with few superiors among those who controlled the military operations in our great national crisis. It is the belief of those who knew him best that if circumstances had given him a more independent command the great reputation which he did achieve would have been greater still.

As a geographer he contributed much to the development of the western country, and especially to the great work of preparing the way for the construction of the Pacific railroads.

In geology, a science of which he was passionately fond and to

whose study he devoted close attention, he advanced original views and generalizations which have attracted favorable notice from men whose life-long labors place them at the head of the profession in this country.

In the science of hydraulics, whether applied to the improvement of our great inland rivers or to the amelioration of the harbors along the Atlantic coast, his investigations and writings class him among the most eminent of American engineers.

An expert in bridge construction, General Warren also devoted much study to the troublesome legal questions which have grown out of the conflicting interests of navigation and railroad transportation on our western rivers, and his exhaustive report upon bridging the Mississippi between St. Paul and St. Louis is a recognized authority consulted by lawyers as well as by engineers.

In several other departments of science which claim the attention of different members of the National Academy General Warren was a reader, and in the advancement of all he felt an interest. He always attended the meetings when other duties permitted; and although his modesty usually kept him from taking an active part in the discussions few listeners formed more just conclusions or were quicker to apply new ideas to practical use in their own specialties.

Such was the man whose seat among us is now vacant. In the maturity of his mental vigor he has ceased from his labors, leaving, I am sure, in the minds of many of his colleagues a sense of personal loss as well as of respectful remembrance.

General Warren was born at the village of Cold Spring, New York, on January 8, 1830. He entered the Military Academy in 1846, and was graduated in 1850 with the second rank in a class of forty-four members. He was at once assigned to the Corps of Topographical Engineers as brevet second lieutenant; promoted to be second lieutenant on September 1, 1854; first lieutenant on July 1, 1856, and captain on September 9, 1861. The two Corps of Engineers having been consolidated by act of Congress in 1863 he became major on June 25, 1864, and lieutenant colonel on March 4, 1879. He died on August 8, 1882.

The rapid settlement of the region west of the Mississippi during the past thirty-five years, and the consequent perfecting of the maps, have thrown into oblivion the great geographical problem presented when the subject of Pacific railroads first attracted earnest attention. Immense areas were then *terræ incognitæ* and others were only

known from the reports of exploring parties ill-supplied with means for accurately mapping their routes. Savage Indian tribes pursued their game and waged war upon each other and upon the few white pioneers throughout thousands of square miles where the iron horse was soon to find his way.

Congress made provision for the systematic exploration of five great routes between the Mississippi river and the Pacific Ocean, each following a different parallel of latitude, and the surveys were conducted by military expeditions commanded by officers of engineers of the army. The dangerous nature of the service may be inferred from the fact that two of these officers met a soldier's death in the line of this duty.

The general direction of the whole work, in 1854, was devolved by the Secretary of War upon General (then Captain) Humphreys, with Lieutenant Warren as principal assistant. The latter had already won a deserved reputation on various surveys upon the Mississippi river, and he now aided his chief in preparing a general report, which, appearing as their joint production, brought to both much professional distinction. He was also specially charged by Captain Humphreys with the compilation of a general map of the entire region from the preliminary reports of the parties and from all existing information. His monograph and map, which finally appeared in Vol. XI of the quarto edition of Pacific railroad reports, is a model of the manner in which such work should be done. Many of the latitudes were fairly determined in the field, but the problem of longitudes involved much difficulty. Warren solved it with extraordinary success, and filled in his map by a system of analyses and counter-checks, based on an intense study of a mass of more or less uncertain data, including reports from the earliest Spanish and French explorers to the latest accurate surveys. Many were in manuscript. Each authority was given weight according to his experience and the means of observation afforded by his instruments; and by this system topography was made available, which otherwise would have been worthless because incorrectly placed on the early maps. It was at this period that our life-long friendship began; and I well remember how the midnight hour often found him hard at work comparing and reconstructing his preliminary tracings or pouring over the old reports for missing data. To extract from a mass of erroneous and contradictory material results which have stood the test of subsequent good work in

the field is no mean test of scientific ability, and this Warren accomplished in a remarkable degree. At intervals while this labor was in progress he himself conducted three explorations in Dakota and Nebraska, traveling many hundreds of miles with small parties among hostile tribes, with his life in his hand. It was in this service that he acquired his strong taste for geological investigations, and where he devoloped that habit of self-reliance and that keen military instinct which subsequently were so conspicuous on the theatre of war in Virginia.

This is not the place to detail his career during the war. He entered the volunteer service as lieutenant colonel of the Fifth New York on May 14, 1861, and rapidly rose by his merits in the Virginia campaigns until on May 3, 1863, he attained the rank of major general, and, shortly after, the command of one of the corps of the Army of the Potomac. He served in that grade until the end of the war, resigning his volunteer commission and returning to duty in the Corps of Engineers when the fighting ceased in 1865. He was brevetted four times in the regular army for gallant services in action, having taken part in seventeen great battles and twenty skirmishes, and been wounded twice. A more glorious record falls to the lot of few soldiers.

It is difficult to convey an idea of General Warren's intense mental activity at this period. On one occasion, when we were lying before Petersburg and most officers were content to rest from the fatigues of the tremendous campaign just closed, although he was then in command of the Fifth Army Corps, he sent me an abstruse mathematical discussion of a problem of forces in pontoniering, written out for recreation. Later during that winter, when we were completely mud-bound, I found him one day at his headquarters at work with a microscope, just ordered from New York, examining some specimens of bacteria. At another time, having myself an artillery command, I was studying the development of Confederate rifled projectiles by collecting unexploded samples thrown into my batteries. Happening to mention this he at once turned over to me about 250 specimens which he had gathered himself with the same object in view. In a word, rest with him always meant activity in a new direction, and to this characteristic was due the surprising extent of his knowledge upon many subjects to which it would naturally be supposed his busy life had barred the door.

When peace returned after our great civil struggle many of the best officers of the Corps of Engineers were lying in bloody graves. The juniors, although experienced soldiers, had had little or no practice in the civil branches of their profession. The consolidation of the two corps and the immense impulse given to internal improvements by the new direction into which the energies of the nation were turned threw a weighty burden upon General Humphreys, then called to the command of the organization. Intimately acquainted with the professional ability and high attainments of General Warren, he naturally turned to him as one of his most trusted officers, and placed upon him responsibilities and labors which would have crushed a weaker man.

Between August, 1866, and May, 1870, General Warren was charged with surveys and examinations with a view to improve the navigation of the upper Mississippi, the Minnesota, the Zumbro river in Minnesota, the Cannon river in Minnesota, and the Fox and Wisconsin rivers; also with reporting upon the construction of railroad bridges across the upper Mississippi and Ohio rivers; also with a detailed survey of the battle-field at Gettysburg; also with the practical operations of improving the navigation of the upper Mississippi; also with the construction of a wagon road from Duluth to the Bois-Fort Indian reservation; also with the designing and partial construction of the bridge across the Mississippi at Rock Island. He likewise served as a member of a board to report upon the construction of a canal around the Des Moines rapids, and as a member of a special commission to examine into the condition of the Union Pacific railroad and branch lines east of the Rocky Mountains, and of another special commission for the same work upon the Union Pacific and the California Central Pacific railroads, and to point out their proper point of junction, and finally as a commissioner to report upon the five last completed sections of the Union Pacific railroad.

In May, 1870, his health having become impaired by exposure and over-exertion, General Warren found himself unable either to continue these labors or to accept the charge of the Lake Survey, which was offered him. He was finally ordered to the charge of a district on the seacoast comprising part of Massachusetts, Rhode Island, and Connecticut, with headquarters at Newport, R. I. This promised to afford him rest and leisure to complete his final reports upon several of the above-named works, which under the pressure

of his multifarious duties had been delayed; but Congress soon appropriated considerable sums for surveys and harbor improvements in his district, and he thus found himself burdened with new responsibilities and in a new field.

Moreover, besides these duties pertaining to the geographical district of which he had charge, others of a specially important character were brought upon him by his high reputation as an engineer. Thus, in 1870, he served on boards upon Ohio river bridges and upon the international bridge over the Niagara, and in 1871 upon alterations in a bridge at Cincinnati and upon the harbor at Chicago; in 1872 upon bridges over the Mississippi and Missouri; in 1873 upon bridges over navigable channels between Lakes Huron and Erie, upon the St. Louis bridge, and upon the Fort St. Philip canal project at the mouth of the Mississippi. In 1874 he was designated by the President as president of a special commission ordered by Congress to report upon the reclamation of the alluvial region of the lower Mississippi, subject to overflow. In 1876 he served on a board on bridges over the upper Mississippi, and in 1878 on the improvement of the Mississippi from the Falls of St. Anthony to Rock Island rapids. He also, in addition to the regular duties of his district, made a survey of the battle-field of Groveton, Va., and prepared certain maps to illustrate the campagn of 1862 in Virginia, for use in the Fitz-John Porter investigation.

This bald recapitulation of the more important duties which engaged the attention of General Warren between the end of the war and the time of his death is sufficient to indicate the character of his professional services. His reports, published in the annual reports of the Chief of Engineers or in Congressional documents, are very numerous. They all bear witness to his clear intellect, his close attention to duty, and his care to award due credit to his subordinates—a matter which with him was a religion.

The writings upon which his scientific reputation will rest, after his early Pacific railroad investigations, are perhaps his final reports upon the Minnesota river in 1874; upon the Fox and Wisconsin river improvements, 1876, and upon bridging the Mississippi between St. Paul and St. Louis, 1878. These rise above technicalities, and show the originality of his mind and the conscientious care he always brought to questions involving research. It is to be regretted that the pressure under which he labored did not allow leisure to elabo-

rate more papers in the same vein. Those who knew him will remember that his conversation about any of his works was full of suggestions which he rarely found time to develop on paper.

In illustration of his contributions to science I shall only advert to a generalization in physical geology which he first announced in a paper read before the American Association for the Advancement of Science at the Chicago meeting of 1868, and subsequently discussed in reports above mentioned.

The Minnesota river and the Red River of the North head in adjacent lakes so slightly separated that the waters of the former in heavy rains find their way in part to the Gulf of Mexico and in part to Lake Winnipeg and thence to Hudson Bay. From its source (Big Stone lake) the Minnesota, although a small stream, flows through a valley varying from one to two or more miles in width, sunk from 130 to 250 feet below the general level of the country. For over 100 miles its bed is partially granitic (probably Huronian) and the bluffs are drift. Its tributaries all discharge through narrow valleys eroded by the present streams, and the same is true of the Mississippi itself above its junction with the Minnesota, but below that point it winds through a continuation of the same broad valley. The detritus brought down into this great excavation by the tributaries is too much for the present volume of discharge to transport, and it is deposited near their mouths, forming dams which tend to transform the river into a series of long lakes connected by rapids and bar-obstructed channels. In a word the tributaries and the Mississippi itself, above the mouth of the Minnesota, are eroding rivers of the present epoch with volumes proportioned to their drainage areas, while the great valley above indicated now filling up with detritus is the bed of an ancient torrent to which the present stream is a rivulet. What has caused the disappearance of this mighty river?

General Warren was the first to comprehend this problem in all its bearings; and bringing to its solution his extensive knowledge of the country and of its geographical features he finally reached the following conclusions, which, supported by his facts and reasoning, are now, I believe, accepted by eminent geologists. I quote his own language substantially as he presented the subject before the American Association for the Advancement of Science in August, 1868:

"Northward from Lac Travers commences a vast lake basin, ex-

tending continuously to the north end of Lake Winnipeg, including this lake, Lake Winnipegoose, and Lake Manitoba. The greater part of this ancient lake bed is now dry, leaving a well-defined beach to mark its former extent. The Red River of the North flows along the lowest line of this bed. The waters of this basin once flowed southward through the Minnesota river into the Mississippi.

"The present level of Lake Winnipeg, according to Mr. Hines, is 650 feet above the ocean.

"To again cause the waters to flow southward with the present levels of the land existing would require the lake to be raised 330 feet.

"It is obvious that this could not be done while the Nelson river outlet existed. There is no good description of this outlet, it never being used for a line of communication; but it is known to abound in rapids and falls, which seem to show its recent origin. If we suppose the ice of the glacial period to have closed this outlet such barrier would have given the lake the whole extent of the basin and caused its discharge southward, but this will not account for all the phenomena observed.

"A more satisfactory explanation of a change of outlet from a southern to a northern one is to attribute it to a northern depression of the basin, for this accounts for the fact that Lake Michigan formerly had a southern outlet through the Illinois river and that Lake Winnebago also had a much greater extent and a southern outlet through the Wisconsin river. The shores of all the lakes show the water to be receding from their southern sides and encroaching upon their northern ones, as such change of level requires.

"This northern depression is known to be going on along the Atlantic coast from New Jersey to Greenland, so that it would seem to be continental in its extent; but further consideration has shown me that all the waters of Winnipeg basin, even if they had continued to flow southward, could not have excavated the passage way now occupied by the Minnesota and Mississippi rivers, and we must go further back in time to reach a sufficient cause.

"In doing this we will first consider the character of the rivers which existed in the periods preceding the glacial epoch.

"During the cretaceous period we know that an ocean extended from the present Gulf of Mexico to the Arctic Ocean, covering a large portion of the space between the Missouri river and Rocky

Mountains. At that time the country through which the upper Mississippi now flows was dry land, and its slopes must have sent its waters westward to that cretaceous ocean. As this continent rose this cretaceous ocean disappeared and the tertiary period began with great fresh-water lakes along the base of the Rocky Mountains. Into these lakes the waters of the upper Mississippi region continued to drain westward.

"The gradual southwestern elevation of the continent throughout the tertiary period is distinctly proved by the deposits of these tertiary lakes.

"The earliest deposits were of least area, and as they became more recent they expanded northeastward, and this action continued, apparently, to the time preceding the glacial epoch. This elevation at the southwest seems to have been in progress from the earliest geological epochs, every contemporaneous formation being found in the mountain regions of the southwest higher than to the northeast.

"Preceding the glacial period, then, all the water courses of the upper Mississippi region were westward and not southward, as now.

"Not only the slope of the land but the great folds of the silurian strata compelled the water to this course.

"Over a great deal of the region thus drained no rocks more recent than the silurian are found, so that it must have been dry land since the silurian period.

"In the immense ages succeeding the time of the silurian oceans these rocks were exposed to all the atmospheric influences; and we can conceive how they must have been cut up by ravines and valleys encroaching on each other in endless confusion, somewhat as we now see them in the bad lands of Nebraska, but on a grander scale.

"Even the hard azoic rocks forming the dry land of the silurian period must have exhibited the most stupendous atmospheric erosions. These preglacial erosions can still be distinguished from those made since.

"When, then, the glaciers came, it would seem that their work was easy, and they have planed down the whole region, removing silurian strata 500 feet in thickness over hundreds of miles.

"The whole upper Mississippi region was the scene of the drift action, and the valleys of pre-existing rivers were filled up and mostly buried out of sight. The existence of a distinct glacial

moraine (unmodified) at Warsaw, on the Mississippi, shows that the glaciers were at least that far south.

"I have determined the southwestern limit of the glacial drift action to be the Missouri river from about the 48th down to the 43d parallel of latitude.

"The modified drift forms the grand Coteau du Missouri lying on its east bank, and the material extends thence northeastward almost continuously.

"From the Missouri river to the Rocky Mountains, over a space varying from 300 to 500 miles in width, no drift is found except that due to local glaciers of the mountains, which in some cases extended for 50 miles east of their bases.

"The existence of this space between the Missouri river and the Rocky Mountains, free from drift, shows that the form of the continent and seas in the glacial time were such as to produce in the climate relations similar to those which now exist, namely: that the mountains to the west intercepted, as they now do, the moisture from that direction, and that the supply for the Mississippi valley came from the south as now, moved with the winds in a northerly direction as now, and left an arid region such as we now have along the plains east of the mountains.

"Since low temperature and moisture combined are required to produce a glacier, it follows that high temperature, or aridity, either of them, would resist their formation and determine their limit.

"If high temperature limited them southward, and aridity westward, the limiting line would have taken a northwest and southeast direction, somewhat as the summer isothermal line now does.

"The motion of the glacial mass must have been along the line of least resistance and towards this limiting line; and the glacial scratchings in the northwest show that the glacial motion was southwest.

"There, then, on that limit a river must have been formed to carry away the melting water from the glacier, and this limit was the Missouri river, and that was the river formed thereby.

"It cut along this glacial limit because all the streams west of it came from the mountains towards it, down the inclined plane, and there their old course was terminated.

"We see what lakes must have periodically formed here, what great barriers must have been formed and burst, one after another, and what deluges the lower valley must have experienced.

"As the glaciers began to retire to the northeast, so long as the general slope of the plain was towards the glacial mass, successive rivers were marked out by it along its western face, and all have a parallelism and are close to each other, and have short tributaries or parallel branches if any. There are, besides minor streams, the James, the Big Sioux, the Des Moines, the Iowa, and Cedar rivers, and finally the Minnesota and the Mississippi, the last of the parallel rivers.

"After the lowest line of the continental valley was passed the glacier would retire, so that the melting water would run directly from it, and so we see all the tributaries of the Mississippi on the east side.

"This direction corresponds with that of the preglacial rivers, and it is probable that many of them here washed out and regained their old beds, such as the St. Croix, Chippewa, and Wisconsin rivers, and so their appearance would indicate.

"The bend of the great valley along the Minnesota river, between Mankato and St. Paul, being at right angles to the main course of all the parallel glacial rivers, would seem to disprove the formation of this river having taken place along the glacial margin, and it probably is the bed of one of these pre-glacial rivers. It lies here in the proper fold of the silurian rocks to have been formed in an ancient valley, but from St. Paul southward the present course of the Mississippi is cut square across the fold in the rocks, and the glacial action is the only explanation of it.

"The manner in which the glacial action produced these excavations was not by abrading the strata with the grinding power of rocks imbedded in the ice, but after the manner in which a block of marble is sawed. The glacier supplied an immense power in the melting water, and into this water it was constantly dropping sharp rocks and sand. The action of falls also played an important part in this operation.

"The waters issuing from a lake have little abrading power, for they have comparatively little rubbing material to operate with. Lakes are only drained by abrading effects produced at waterfalls receding up stream.

"The waters issuing at the old southern outlet of Lake Winnepeg could make no impression on the granitic bed of the Minnesota. Had this material been soft like the silurian rocks lower down in its course, or like the tertiary and cretaceous rocks through

which the Missouri has cut its way, then this part of the valley might have been worn away as the others have been, and we should still have the drainage of all the Winnepeg basin to the southward.

"A cut of 400 feet at Big Stone Lake would have drained the whole Winnepeg basin, nor would the banks then have been as high as those of the Missouri at the Bijou Hills, which are 800 feet above the water of the river. The slope of the Missouri is more than double that of the Mississippi, and hence the water of the Missouri river is several hundred feet higher than that of the Mississippi at points in the same latitude in their upper courses.

"An examination of the bluffs along the Mississippi shows that the space between them is, on the whole, quite uniform in width, gradually increasing downward, being about a mile at Big Stone Lake, and reaching six to ten miles at Commerce, below which the space widens out to from forty to sixty miles.

"Sometimes the river, as at the 'Grand Tower' and 'Le montagne qui Trempe-à-leau,' and several other places, is found flowing between bluffs not even a mile apart, but the bluffs on one side or the other are always found to be a detached mass, and the main valley exists there too.

"Two remarkable exceptions to this occur at the rapids, one at Keokuk, the other at Rock Island. Without lengthening this paper, as it necessarily would to go fully into an explanation of these, I will state that, after being long puzzled by them, I discovered that the whole valley had been covered with an extension of the Gulf since the glacial period as high up as Savannah or Dubuque; that the silt brought in by the Des Moines river in the one case, and the Iowa and Rock rivers in the other, during this period, filled up entirely the valley cut out by the great glacial river, and that when the land rose again the Mississippi could not at these regain its old bed, so it had to cut a new one, and this is not yet completed.

"The space between the bluffs at these two places has the width the present river requires, and it is so nowhere else in its whole course."

This hypothesis of a continential southern elevation and northern subsidence, extending through a vast period of time and still probably in progress, admits of verification in districts not surveyed in detail by General Warren; and in his final report upon the Minnesota (1874) he ventured to predict that evidence would be found in the Maumee valley to prove that that river has wholly drained an

ancient lake to Lake Erie, as the Fox river now partially drains Lake Winnebago to Green Bay, the discharge of both lakes having been formerly southward. Such evidence would be "the existence of an ancient lake shore and a gorge somewhere along the Maumee if rock is encountered in its course." This prediction was verified by railroad surveys executed by Mr. Thomas P. Roberts, C. E., as reported by him in a letter to the *Toledo Blade* dated February 23, 1876.

General Warren was elected, before the war, a member of the St. Louis Academy of Sciences; in 1867 a member of the American Philosophical Society, Philadelphia; in 1876 a member of the National Academy of Sciences. In 1874 he was elected a member of the American Society of Civil Engineers, and for a time was a member of its Board of Direction. He joined the American Association for the Advancement of Science in 1858.

This imperfect sketch outlines the professional services and mental traits of an officer whose memory will long be cherished by his associates. Personally he was a firm friend and a generous enemy. His refinement of character is well illustrated by his love of flowers. To him they were living impersonations of beauty whose study was a never-ending source of pleasure. While attending our April sessions in Washington his favorite resort after adjournment was to the magnolia tree near the fountain in Franklin park, and he seemed to never tire of admiring its wonderful beauty at this season.

After the death of his father in 1859 General Warren tenderly discharged toward his mother and younger brothers and sisters every duty which devolved upon him as the head of the family. In 1863 he married Miss Emily F. Chase, of Baltimore. He leaves to her and to a beloved son and daughter a legacy of honor more precious than wealth.

When death has removed a cherished friend it is a trait of human nature to pass over what was heroic and great in his character and to cling to the memory of his kindly acts to the poor and unfortunate. The life of General Warren was full of such actions; and I cannot better close this tribute than by mentioning one out of many which came to my knowledge.

In the summer of 1855 he served as the Engineer officer of General Harney's staff in a successful Indian campaign in the Dakota country to avenge the massacre of Lieutenant Grattan's party, and was present at the resulting action near Blue Water

creek. During the attack he was with the advanced guard, but afterwards he devoted himself to the care of the wounded. He wrote to his brother: "After the fight I was on the ground taking care of the wounded until dark, and I hope relieved a great deal of innocent suffering—I mean the injured women and children, for all the men were killed. I was all blood at night from carrying the bleeding children in my arms. The soldiers left on the ground aided me, whenever I asked, in bringing them to water, bathing their wounds, and putting them under shelter. It was a sight to make one shed tears, but it could not be helped. The Indian men fired after ours had stopped, and killed two soldiers, and in destroying these men the women suffered."

Not all the bloody battles of the civil war could harden this kindly nature. During the bitter cold of the last winter, before Petersburg, it became necessary for his corps to execute certain movements upon the extreme left, which occasioned untold misery, especially to the wounded. Referring to this in a private letter he wrote: "I do not feel it much in my own person, but I sympathize so much with the suffering around me that it seems at times I can hardly endure it." While his soldiers admired his personal dash and trusted implicitly to his skill as a general, they were ready when the occasion offered to throw themselves between him and death, *because they loved the man.*

MEMOIR

OF

WILLIAM A. NORTON.

1810-1883.

BY

W. P. TROWBRIDGE.

PREPARED FOR THE NATIONAL ACADEMY.

BIOGRAPHICAL MEMOIR OF WILLIAM A. NORTON.

Professor WILLIAM AUGUSTUS NORTON was born in East Bloomfield, New York, October 25, 1810, and died at his home in New Haven, Connecticut, after an illness of but a few days, within a month of the completion of his seventy-third year.

His boyhood was passed in that part of Western New York which was, even in those early days, noted as being one of the centres of literary culture of the State, and which has produced so many men eminent in literature, science, and jurisprudence.

Of his early days, one of his life-long friends, who knew him intimately in his boyhood, writes: "I can recall nothing remarkable except his devotion to study and the sweet and sunny temperament which made him so great a favorite during his later years."

It would hardly be possible to find more fitting words to describe the predominant traits of Professor Norton's character than this simple tribute from one whose affectionate regard continued from their common childhood until his death. His "devotion to study" through a long and active career, uninterrupted for more than half a century, kept him constantly in the foremost rank of scientific writers and investigators, while the sweet and sunny temperament of the boy became developed into those high attributes of a strong manly character which gave him the powerful influence which he always held and maintained as an instructor of youth. During the whole of his long and active career as a teacher in the highest departments of the mathematical and applied sciences it was one of the remarkable traits of his character that he seemed to draw his students near him and secure their devotion to their studies, not only by his own enthusiasm in his work and his skill in presenting his subjects, but by a rare combination of personal accomplishments, in which dignity of demeanor and cheerful sympathy with those under his instruction invited the utmost familiarity consistent with serious and honest work on the part of the learner.

Professor Norton was graduated from the U. S. Military Academy at West Point with high honors, July 1st, 1831, in a class which embraced among its distinguished members Professor Roswell Park, Colonel Henry Clay, Jr., General A. A. Humphreys, and others,

whose reputations have become national. He was assigned to the 4th Artillery, but was immediately ordered to the Military Academy to act as assistant professor of natural and experimental philosophy, which position he held until he resigned from the army in 1833. During this time he was temporarily detached from the Academy for a few months to serve in the Black Hawk expedition of 1832.

His resignation was the result of a call to the professorship of natural philosophy and astronomy in the University of the City of New York. His reputation as a teacher in science was thus prominently recognized at a time when positions of such responsibility were rarely offered to young men of his age. Professor Norton remained at the University of the City of New York six years, when, in 1839, he was called to the chair of mathematics and philosophy in Delaware College, Newark, Delaware. He occupied this position for ten years, becoming president of the college during the year 1850.

In 1850 the professorship of natural philosophy and civil engineering in Brown University, Providence, Rhode Island, was offered to President Norton and accepted by him, and he removed to Providence, where he remained until 1852, when he was elected professor of civil engineering in the Sheffield Scientific School of Yale College. He entered upon his duties in Yale College in the autumn of 1852 with a class of students who had followed their instructor from Brown University.

"Since then to the day of his death," writes one of his old pupils and afterwards his colleague in the Sheffield Scientific School, Professor A. J. Du Bois, "he has ever been found at his post of duty, and many of his old pupils, now filling responsible positions throughout the length and breadth of our country, will testify to the practical value of his instruction, to his great capacity as a teacher, and to his character as a man." "A teacher's best testimonial is the esteem and respect of his pupils, his best reward their love and confidence; and in this respect Professor Norton stood very high."

"No teacher ever had more loyal students. It has been the privilege of the writer to be once his pupil, afterwards his colleague, and always his friend; and during that period of seventeen years he has never met or known any student to entertain any doubt of Professor Norton's entire impartiality, his skill and fidelity as a teacher, or his friendly interest as a man." "With a manner peculiarly genial and endearing in the class-room, frank and manly

always, and sometimes almost jovial, he made every student feel that his instructor was also his personal friend." "Ever ready with suggestions, advice, and encouragement, always young at heart himself and believing thoroughly in the young men he taught, he was much more to them than the subjects he taught, and his personal influence was better than books."

Testimonials like this might be multiplied, and the writer of this memorial for the National Academy begs to add his own tribute of affection and regard, not only as a former colleague in the staff of instructors of the Sheffield Scientific School, but as a near neighbor and friend for many years. Whatever may be the loss to science, to the cause of education, and to the community in which he lived his death falls most deeply upon those who knew him best in those unreserved social relations which bring men nearest to each other—the relations of neighbors, friends, and companions.

In all these he was noble and chivalric, warm-hearted, sympathetic, and true.

Professor Norton's contributions to scientific literature began at an early day. While he was a professor in the University of the City of New York he prepared a work on astronomy, designed as a text book in colleges and academies. This work, embracing over four hundred pages, was published by Wiley & Putnam in 1839, and was entitled "An Elementary Treatise on Astronomy."

It gave a systematic and comprehensive exposition of the theories and the more important practical demonstrations connected with astronomical problems, and also some of the more useful astronomical tables.

Of this work it may be said that it was designed to meet the wants of the student of practical astronomy, and was not intended to be a popular work. It undoubtedly constituted one of the best sources of practical knowledge of the subjects treated that existed at the time in this country. Great interest was then felt in geographical explorations and the vast unknown regions of our own country. Since then the field of operations of so many costly and important exploring expeditions and surveys seemed to call for methods as well as men in the near future and demanded an exposition of the practical branches of astromomy suited to the rising generation of students and explorers. As a contribution to the scientific wants of the country at that time this work of Professor Norton was in

every respect timely and appropriate in its general features and in the treatment of the subject.

In the fourth edition, published in 1881, the tables were revised, corrected, and enlarged, and the chapters which treat of astronomical instruments, comets, the fixed stars, and the zodiacal light were almost wholly rewritten.

Professor Norton published, in 1858, another work entitled a "First Book of Natural Philosophy and Astronomy," and it was during the period of his most active work as a teacher in Yale College that he prepared the numerous contributions to the advancement of science which gave him increased reputation, and on the merits of which he was elected to the National Academy of Sciences.

His scientific memoirs were mostly published in the American Journal of Science, but occasionally in other journals, or were read before scientific societies of which he was a member.

The following list comprises some of the more important of these contributions:

Terrestrial Magnetism. Am. Journal of Science. Second Series. Vol. IV.

Periodical Variations of the Declination and Directive Force of the Magnetic Needle. American Journal of Science, 1855.

Ericsson's Caloric Engine. American Journal of Science, 1853.

Donati's Comet. Two Memoirs. Am. Journal, 1859, 1861.

Molecular Physics. Two Memoirs. Am. Journal, 1864, 1872.

Principles of Molecular and Cosmical Physics. Am. Journal, 1870.

The Corona Seen in Total Eclipses of the Sun. Am. Journal, 1870.

Physical Constitution of the Sun. Am. Journal, 1871.

Dynamical Theories of Heat. Am. Journal, 1873.

Laws of the deflection of beams exposed to a transverse strain. Tested by experiment. Proceedings of the American Association for the Advancement of Science, 1870.

Physical theory of the principle of the lever. Proc. of the Am. Association, 1870.

Results of experiments on the set of bars of wood, iron, and steel, after transverse stress. Two papers read before the National Academy of Sciences, April, 1874, and April, 1875.

A succinct statement of the conclusions of the two papers. Published in the Am. Journal of Science, April, 1876.

Result of experiments on contact resistance. Read before the National Academy of Sciences, April, 1876. Pub. in American Journal, June, 1876.

It would be hardly possible within the space which is allotted to this memorial to do full justice to these scientific papers by attempting to set forth in any manner of detail their valuable features.

They belong to the history of modern scientific progress, in which field, notwithstanding the constant demands on his time as a teacher, Professor Norton did his full share of work.

It is to be especially noted of them all, however, that they were on special subjects which, at the time they were written, stood in the front rank of scientific inquiry, and occupied the attention of the best minds of the period.

A few only of these papers can be discussed in illustration of these facts.

Among the first, in point of time, appeared the paper on Ericsson's Caloric Engine, 1853.

The important developments of the dynamic theory of heat by Clausius, Rankine, Joule, and others, the first accounts of which were published in the English and European scientific journals, had but just reached this country; and, indeed, the full significance of the discoveries had scarcely yet been fully appreciated by scientific men anywhere, when Mr. Ericsson, with the far-reaching practical turn of a mind which has given to the world so many valuable improvements in mechanical constructions, conceived the idea that by the use of air in place of steam as a medium of heat in the cylinders of engines not only would great economy but other incidental advantages of no less importance result from the process. With the boldness in putting his conceptions into practice and the wonderful skill as a mechanical engineer which have always characterized his labors, and which have led him to so many triumphs, Mr. Ericsson planned the construction of an ocean steamship to be propelled entirely by heated air. The effort, the ingenuity of the mechanical constructions, and the partial success attained were worthy of the genius of the great engineer.

But there were elements in the problem proposed by Ericsson of a character intimately connected with the newly-developed theory of heat which were unseen and unsuspected by him, the want of knowledge of which rendered his great experiment a practical failure.

An experiment intended to revolutionize the motive power of sea-going vessels, planned on such a large scale, and executed at great expense, did not fail to attract the notice of scientific men; and yet there were few in this country who had the ready preparation required to analyze the difficult problems involved. Captain J. G. Barnard, of the U. S. Engineers (afterwards General Bar-

nard) and a member of this Academy, and Professor Norton, each entered zealously upon the discussions independently of each other, and each arrived at the same general results, although Professor Norton had more to do with the practical testing of the engines of the new ship "Ericsson."

Professor Norton found the energy developed by the ponderous engines of the "Ericsson" to be 300 horse power only.

The amount claimed by the inventor previous to the trial was 600 horse power—double the power actually developed. The volume swept through by the working pistons per indicated horse power was 108 cubic feet per minute. The investigations of Professor Norton brought out several important facts. First, the great bulk of the engine for a given power and the smallness of the mean effective pressure compared with the initial pressure, requiring great strength and weight as well as bulk. The quantity of fuel consumed for each horse power per hour was found by Professor Norton to be 1.87 lbs. of anthracite coal. The efficiency of heated air as a fluid in the cylinder exceeded that for steam as the latter was used at that time, but the difficulty of heating the air without great waste of heat proved to be another obstacle to success. These difficulties have never yet been remedied, and the hot-air engine has ceased to be considered a prime mover of great importance.

Professor Norton's investigations in connection with the "Ericsson's" engines have been repeatedly referred to since, by writers on prime movers, as having, at that early day, established truths in regard to hot-air engines unfavorable to their use, at least on a large scale, which have become universally settled convictions.

Professor Norton's memoirs on the probable cause of action which produces the tails of comets (American Journal, 46th volume) gained for him the reputation of thoughtful and skillful investigator in a class of problems connected with the highest branches of physics.

His ideas of a repulsive action on the sun, in the matter of the comet, combined with the joint repulsive action of the nucleus, was worked out in such a way as to show the forms assumed by the tails of comets under certain conditions, particularly that of the Donatti comet.

The same idea had, unknown to Professor Norton, been suggested by Bessel, but the latter did not include in his theory the joint re-

pulsive action of the nucleus of the comet, nor did he develop the theory to the same extent as Professor Norton.

The Proceedings of the American Association for the Advancement of Science for 1870 contains a paper by Professor Norton of great interest to engineering science on the "*Laws of the deflection of beams exposed to transverse strains, tested by experiment,*" and two papers of the same character were read before the National Academy of Sciences, April, 1874, and April, 1875. The experiments on which these papers were based were conducted with great care, by means of a delicate apparatus devised by himself, and the results obtained indicated the existence of laws connected with the set and strength of materials under transverse stress which had not before been suspected, and constitute important additions to knowledge on these interesting subjects.

A succinct statement of the results of his experiments and of the general conclusions as set forth in his several papers on the subject appeared in the American Journal of Science, Vol. XI, June, 1876.

Of his papers on Molecular Physics it may be said that he left unfinished a work to which the most earnest study of his life had been devoted. The papers on that subject, alluded to above and published from time to time in the American Journal, were but studies upon which he had built, in his own mind, a complete work, already begun and partly executed at the time of his death. This work he regarded as of greater scientific importance than all other efforts of his life, and he hoped by its publication to render a lasting and important benefit to science in connection with a subject which, though still to a great extent speculative, seems to be gradually yielding to the continued advances of mathematical and physical investigation. Few men have devoted more thought to a subject which, from its being peculiarly devoid of popular interest, must continue perhaps for a long time to present to its votaries the certainty of controversy only, instead of praise or any hope of sympathetic appreciation. The inherent difficulties of the investigations seemed only to stimulate Professor Norton during the later years of his life to continued study, until his conceptions had taken clear and definite shape capable of being formulated into laws expressed mathematically. Unfortunately the manuscripts he left, comprising the first two or three chapters only of his intended work, are not sufficient to enable any one else to complete the work, or even

to do it justice in a partial presentation of the subject. The general basis on which he intended to build may, however, be understood from the following general summary or statement, which includes the fundamental hypotheses upon which he bases his theories.

1. "All the phenomena of material nature result from the action of force upon matter."

2. "All forces in operation in nature are traceable to two primary forces, viz: Attraction and repulsion."

3. "All bodies of matter consist of separate indivisible parts, called atoms, each of which is conceived to be spherical in form."

4. "Matter exists in three forms essentially different from each other: These are, first, ordinary or gross matter, of which all bodies of matter directly detected by our senses, either wholly or chiefly, consist; second, a subtile fluid, or ether, associated with ordinary matter, by the intervention of which all electrical phenomena originate or are produced. This electric ether, as it may be termed, is attracted by ordinary matter, while its individual atoms repel each other; third, a still more subtile form of ether, which pervades all space and the interstices between the atoms of bodies. This is the medium by which light is propogated, and is called the luminiferous ether, or universal ether. The atoms, or "atomettes," of this ether mutually repel each other, and it is attracted by ordinary matter, and is consequently more dense in the interior of bodies than in free space."

5. "Heat in all its recognized actions in matter manifests itself as a force of repulsion."

Hypotheses like these must be assumed, in order to facilitate investigations concerning the laws of phenomena as to the occult molecular structures and motions of matter with which such phenomena are supposed to be connected, and the direction of Professor Norton's investigations were in an advanced line of thought, which is attracting more and more the attention of physicists.

Throughout a life thus devoted to duty as a teacher and to the advancement of science Professor Norton was cheered and sustained by the companionship of one who sympathized with all his labors and with all the good impulses which filled the measure of his days.

In 1839 he married Miss Elizabeth Emery Stevens, of Exeter, New Hampshire, who survives him, beloved and cherished by a large circle of friends for her estimable character, and especially dear to them now in the time of her affliction.

Those who have partaken of the hospitalities of their cheerful

home in New Haven, or who have been welcomed to their little hill-side summer cottage overlooking the beautiful lakes and valleys of Holderness, New Hampshire, will ever remember the "unity of spirit and the bond of peace" which pervaded their lives, and the cheerful gaiety, so natural and unaffected, that gave a charm and delight to their friendly greetings.

Professor Norton belonged to that rare class of men who in pursuing the even tenor of their duties to the end of long and laborious careers, leave as their best and most precious legacies memories and records of lives without reproach, and of unselfish devotion to their duties and to their fellow-men.

MEMOIR

OF

ANDREW ATKINSON HUMPHREYS.

1810-1883.

BY

HENRY L. ABBOT.

READ BEFORE THE NATIONAL ACADEMY, APRIL 24, 1885.

BIOGRAPHICAL MEMOIR OF ANDREW ATKINSON HUMPHREYS.

Mr. President and Gentlemen of the Academy:

Another honored name among those of the original fifty corporators of this Academy has been stricken from our membership by death. General Humphreys was eminent both as a scientist and as a soldier, a man of broad and liberal views, of commanding intellect, and of the highest personal honor. Official station and strength of character enabled him to do much to promote American science and to advance the material prosperity of the country.

Under obligations to him of no ordinary nature almost since my boyhood, filled with respect for his character and with admiration for his genius—which intimate professional and personal relations for twenty-nine years only served to enhance—I have shrunk from the duty of preparing this memoir, in the fear that the expression of what is nothing but the truth may seem to be the extravagant eulogy of friendship. I ask you to believe that I shall conscientiously avoid anything like exaggeration, which would be most unworthy of him and of this Academy.

Andrew Atkinson Humphreys was born in Philadelphia on November 2, 1810. His great-great-grandfather, emigrating from Wales in 1682, settled in Haverford township, near Philadelphia, where the family still own land which has never passed from their possession. His grandfather and father were both Chief Naval Constructors. The former, the first officer appointed to that grade in our service, was the leading naval architect of his day in this country, and he made the plans upon which were constructed the Constitution and her five sister frigates, which carried the stars and stripes with such distinction in the war of 1812.

As a boy, the subject of this sketch was active, bold, and too full of fun and frolic to devote his attention closely to books. His first serious study was done at the Military Academy at West Point, to which he was appointed in 1827. Even at that age his mind was

not fully developed, and he was graduated in 1831 with the thirteenth place in a class of thirty-three members. Our late colleague, Professor William A. Norton, of Yale College, was his classmate.

Upon leaving the Military Academy Lieutenant Humphreys was assigned to the 2d Artillery. After serving chiefly in South Carolina, Georgia, and Florida, and taking an active part in the Florida war, his health broke down and he resigned his commission on September 30, 1836.

The Topographical Engineers, constituting at that time a distinct bureau of the War Department, were increased in numbers and organized as a corps by the act of July 5, 1838; and the young officer, who, since his resignation, had served as a civil engineer under Major Hartman Bache, was appointed first lieutenant to fill an original vacancy in the new organization on July 7, 1838. For six years he had a varied experience in surveys, harbor improvements and bridge building, and as assistant in the Bureau of Topographical Engineers at Washington. While serving in the latter capacity in 1843 it became his duty to prepare the first project for the extension of the National Capitol, and his design in its essential features much resembles that ultimately adopted and now embodied in brick and marble. In 1844, upon the application of Professor Bache, he was detailed as assistant in charge of the Coast Survey Office. Here he remained until 1849, taking a very active part in organizing the Coast Survey upon its permanent basis. His services were so highly appreciated that Professor Bache not only recommended him for promotion by brevet when they terminated, but also urged the appointment in the following language, quoted from the annual report of the Survey for 1853:

"This officer was placed in charge when the augmentation of the scale of the Coast Survey was begun, and devoted himself with untiring assiduity and most remarkable success to the difficult task imposed upon him. His health suffered so seriously from the accumulated labors which he undertook that he was finally obliged to leave the work. His services were so fully shown by the condition to which he had brought the office during his charge of it that I simply discharged a duty in recommending him for a brevet on retiring. The varied and complicated duties of the several departments of office work require not only professional knowledge of a high order, but intense application and very considerable administrative power.

"The new form of organization to be given to the different parts of the office rendered Captain Humphreys' duty one of even greater than ordinary difficulty, and he discharged it with success, regardless of the gradual undermining of his health. As this duty is imposed by law on the officers of the army, I respectfully submit that for distinguished execution of it he should have the reward appropriate to the officer, a brevet."

It was not until 1850 that Captain Humphreys, after eighteen years of intense application to the duties of his profession, and with judgment ripened by practical experience in many different branches, saw opened before him a field for distinction in original research and independent administration.

By an act approved September 28, 1850, the General Government granted to the several States bordering upon the Mississippi river the swamp and overflowed lands within their limits, to provide a fund for reclaiming the districts liable to inundation. Vigorous action was at once started throughout the entire region. The people of Louisiana, alarmed lest the embanking of the vast lowland districts above them should so concentrate the floods as to overwhelm their own fertile fields in a common destruction, invoked the aid of the Government to conduct surveys and investigations looking to a system for their protection. From this movement the Delta Survey had its origin. Congress made two appropriations, $50,000 in 1850 and $50,000 in 1852; and with these, in modern estimation, most inadequate means Captain Humphreys conducted for ten years a series of researches which accomplished their object, and which have placed his name high on the list of the distinguished hydraulic engineers of the world.

The problems presented to Captain Humphreys for solution were most intricate. Even the fundamental laws governing the flow of water in natural channels, as laid down by the best authorities, were not based upon experiments sufficiently extended to warrant confidence. The data as to cross-sections, slope, volume of discharge, matter in suspension, etc., for this particular river were all unknown. The extent to which the great bottom lands acted as reservoirs to reduce the volume of the maximum flood wave as it traversed the unleveed districts was in dispute even upon theoretical grounds, while of the actual facts nothing was established. The topography of the district was based upon rude surveys unworthy of confidence where precise information was essential to a proper

discussion. The records of previous floods were meagre, and many of them were only to be collected by personal inquiry throughout a region vast in extent, and much of it sparsely settled by a population wedded to absurd hydraulic theories which colored their statements and compelled the investigator to adopt a system of cross-examination more akin to that in the courts than to questions in ordinary practical engineering. The river itself, the resultant of immense forces whose laws of action were unknown, flowed through the country, eroding the banks on one side and reconstructing them on the other, in defiance of the puny efforts of the riparian proprietors, and sometimes in ways apparently so contradictory as almost to justify the sufferers in personifying the river as an evil spirit, which periodically reared his tawny front from the chasm where he writhed in uneasy slumber at low water to work malicious mischief upon their homes and fertile fields. In addition to this great problem of protection against floods, the investigation of another question —that of improving the channels over the bars at the mouths of the river—was soon added to Captain Humphreys' labors.

After a hurried reconnaissance of the region he organized three parties—one to make a minute topographical survey of the river banks between New Orleans and Red river, including accurate lines of level; another to make a hydrographic survey of the river in the same region, including the measurement of cross-sections, the gauging of discharges, and the study (original with Captain Humphreys) of the character and quantity of the material pushed along the bottom, and a third to perform systematic hydrometric work near New Orleans daily for a couple of years. Gauge rods for measuring the oscillations of the water surface were also established throughout the entire extent of the delta. The amount of sedimentary matter carried in solution was observed daily for a couple of years. The discharge of several crevasses was determined by measurement. Like investigations were inaugurated at the several passes to determine the laws governing bar formation where the river water enters the Gulf.

Captain Humphreys gave the closest personal attention to the work of these several parties, passing from one to the other continually and correcting all omissions or misapprehensions. His written instructions, which have never appeared in print, are most minute, and might well serve as models in conducting similar work. They cannot fail to impress the reader with his firm grasp of the subject

and his care to include every element which might enter into the ultimate discussion of the results. These arduous labors performed under a burning sun, for which his sedentary life in Washington had ill prepared him, were suddenly terminated by a *coup de soleil* in the summer of 1851. This shock completely prostrated him and compelled his temporary relinquishment of the direction of the work. After the loss of the master spirit the operations soon fell into confusion, and the field work was brought to an end, leaving much which had been projected unperformed.

For a time Captain Humphreys' physical condition was distressing. His nervous system, overtaxed by continuous mental labor for several years, demanded absolute rest; and all the loving ministrations of home were needed to prevent the ambitious spirit from chafing itself to death under so unwonted a check. When at length reaction commenced, and returning strength made idleness no longer endurable, he sought and received permission to visit Europe, with instructions to examine its delta rivers and to learn what the experience of centuries had taught as to the immediate and ultimate effects of different methods of protection against inundation. Thus the investigations committed to his charge profited in the end by what at first seemed to be a fatal interruption.

In the summer of 1854 Captain Humphreys returned with health restored and eager to resume operations on the Mississippi. This was not to be. The great question of a Pacific railroad had excited popular enthusiasm, and the Secretary of War had been charged with making the surveys and investigations needful to determine the comparative merits of the different routes and the probable cost of each. He knew and appreciated Captain Humphreys' ability, and insisted that he should assume direction of the work as his own confidential adviser—retaining, however, charge of the Delta Survey, which was thus temporarily restricted to the reduction and discussion of data already collected.

It was at this time (October, 1854) that my good fortune placed me, a recent graduate from West Point, under the orders of Captain Humpheys. General Warren, then a second lieutenant, and myself were the only officers at that time on duty with him in the office of Pacific Railroad Surveys, but the work was pushed forward by him with great energy.

Captain Humphreys was absorbed in the preparation of his general report, collecting his materials from the manuscript reports,

incomplete maps and profiles, and verbal explanations of the several chiefs of the different routes, and from a voluminous correspondence with the chief engineers of the important railroads east of the Mississippi, and with leading merchants and business men. Congress soon assembled in short session, and the throng of Senators and Representatives eager for the latest information rendered close application during the day well nigh impossible. Our real work was largely done at night, and under pressure which can hardly be overstated. The precise advantages and disadvantages of the several routes, the estimates of their relative cost and relative working expenses, the questions of water and fuel, and more generally the demands and probable traffic to be accommodated, all had to be studied; and hasty penciled "memoranda" of points to be investigated came at all hours from Captain Humphreys, whose grasp of the subject and admirable judgment produced an impression on me which thirty years have only deepened. His mind worked like a beautiful machine, neglecting nothing, forgetting nothing, and so rapidly bringing order out of chaos that the work took shape visibly from day to day. The preliminary report was completed before Congress adjourned; and subsequent experience has amply confirmed the correctness of its conclusions and the wisdom of its recommendations.

New parties (to one of which I was attached) were soon sent into the field under the direction of Captain Humphreys, who shortly found himself at the head of a sub-bureau of the War Department charged with all the numerous explorations and surveys west of the Mississippi. Other important matters were often referred to him for special reports by the Secretary of War, who highly appreciated his knowledge and ability. In 1856 he was also appointed a member of the Light-house Board, which largely added to his labors.

In 1857, upon his application, I was ordered to report as his assistant upon the Delta Survey. He had provided himself with a little private room to which he could escape occasionally from his office in the War Department to study the old records, and he was bitterly chafing at the constant interruptions to investigations which he still regarded as the great scientific work of his life. After he had been struck down in 1851 the field work had not been carried out in all respects according to his plans, and the subsequent office reductions had shown that links were missing in the chain of evidence which could not be supplied without resuming operations

upon the river. Fortunately his economical management of the appropriations had left sufficient funds available, and he soon drew up a project for me to carry out in the field. This project was a marvel of forethought that left no gap to be regretted in the subsequent elaborate discussion of the problem, of which the general scope could only be inferred at that date.

The project contemplated daily measurements of the discharge of the Mississippi river near the mouth of the Ohio, and at a point between the influx of the Yazoo and Red rivers; lines of levels across the great Yazoo and Tensas bottom lands, to determine their reservoir capacity; the erection of numerous gauge rods throughout the alluvial region, for recording the daily changes of level of the river; full information as to the daily contributions of the tributary streams; accurate measurements of any crevasses which might occur during the approaching high water; numerous cross-sections of the river at points distributed throughout the entire alluvial region; resurveys at important localities, to learn precisely what changes had occurred since the date of the old measurements; the collection of all possible data as to former floods, and full records of the actual condition of the levees from Cairo to the Gulf, with the dates and history of their construction and the local systems upon which they had been built. In a word the finger was to be firmly placed on the pulse of the great river, and every symptom of its annual paroxysm was to be noted. Very fortunately one of the greatest floods on record occurred, and the observations thus became invaluable for the purpose for which they had been planned. Simultaneous observations at the passes were carried on by Mr. C. A. Fuller, under the immediate direction of Captain Humphreys.

The reduction of these records, augmented by authentic information from every available source, was a work of immense labor and of profound study. The results are now known to the world in the published report, of which two complete and one abridged edition have been printed in this county, while translations into most of the principal languages of Europe have appeared abroad. Respecting this report I have only one word to say. Captain Humphreys had earned the reputation which led to his being entrusted with and continued in the direction of so responsible a work by long years of intense and exhausting mental labor. He had nearly sacrificed his life in its prosecution while I was yet a young cadet beginning my course at West Point. As his assistant during

the last for years of the work, I had simply performed my duty to the best of my ability. Most men would have considered a complimentary allusion to these services in the introductory letter an ample reward. This was not his way of thinking, and he placed my name with his own on the title page. Is it wonderful that a man who to the highest professional attainments united so generous and noble a nature should have bound his associates to him with respect and love stronger than links of steel?

The report was completed at the last moment before the outbreak of hostilities in 1861. Of General Humphreys' war record this is not the place to speak. To courage of the highest order, both moral and physical, he united the energy, decision, and intellectual power which characterized him in civil administration. These traits, joined to a thorough knowledge and appreciation of the principles of strategy and grand tactics, fitted him for the highest military responsibilities; and when peace was proclaimed he had few equals, and no superiors, among the generals developed by the war. His service throughout was with the Army of the Potomac, in which he rose to the command of an army corps. If fortune had favored him with independent command, it is certain that the country would have been the gainer.

In the winter of 1865–66, with his full rank as major general of volunteers, he was sent to the alluvial region of the Mississippi to determine what could best be done to repair the ravages of the war in that region, where the levees had suffered much from neglect as well as from the great flood of 1862. His report, although brief, is a valuable historical document.

He had now risen by regular promotion to the grade of lieutenant colonel, the two corps of engineers having been consolidated during the war. On August 8, 1866, he was appointed brigadier general and chief of engineers, *vice* General Delafield, retired. He discharged the duties of this responsible position for a period of thirteen years, until he was placed on the retired list at his own request on June 30, 1879.

It is a matter of importance to American science that the office of chief of engineers shall be held by a man of broad views, who appreciates its needs and is interested to promote its progress. I am sure that the members of this Academy interested in geology, zoölogy, and botany appreciate the assistance which General Humphreys was both able and willing to render in advancing their sev-

eral specialities. During the twenty-five years in which the exploration of the vast region west of the Mississippi was most active, including the Pacific railroad and other surveys before the war and the King and Wheeler surveys since its close, no man had more power to aid or was more interested in aiding these branches of research than General Humphreys. In the field of hydraulic engineering as applied to the improvement of our rivers, harbors, and internal routes of communication, in which the material interests of the country have so much at stake, he was equally active. During much of this time the burden of his great responsibilities deprived him of the leisure needful for individual research, but it is no small matter to have a scientific man and a friend of science in a position so influential and so important.

In the system of sea-coast fortification General Humphreys' administration marks an important era. Our late colleague, General Barnard, in his eulogy of General Totten, printed in the first volume of our Biographical Memoirs, has admirably outlined the life work of that distinguished engineer, to whom the country owed a system of fortification more nearly perfect and comprehensive than any adopted in Europe in his day. But the advance of science respects neither man nor his works. General Totten's massive masonry towers served their purpose and protected our seaboard from insult while he lived, but their efficiency died with him. Improved processes in metallurgy and a better understanding of the principles of gun construction and of the chemistry of explosives have placed under the control of modern fleets—

> "Such implements of mischief as shall dash
> To pieces, and o'erwhelm whoever stands
> Adverse, that we shall fear they have disarm'd
> The Thunderer of his only dreaded bolt."

The duel of the *Monitor* and *Merrimac* off Newport News in 1862 marked an epoch no less decisive than that which stripped the coats of mail from the horsemen of the middle ages and created the infantry of to-day.

General Humphreys met the changed conditions with good judgment. He convened a board of eminent engineers, with General Barnard at its head, to investigate the subject in the most thorough manner, both theoretically and by experiment. The result was the present system, which consists in obstructing the channel by electric torpedoes flanked by the old guns in the old casemates, but defended

by modern ordnance mounted in barbette on depressing gun-carriages and covered by mounds of earth. This system was never designed as a finality, but only as a temporary expedient to give protection to the seaboard until the struggle between guns and armor had reached a more definite stage. General Humphreys approved and carried it out, so far as the insufficient appropriations of Congress would allow. He also organized an efficient submarine mining system and a school of application for research in professional matters and for supplementing the West Point course in points where engineering science was treated too briefly from want of time.

General Humphreys' administration of the civil branch of the duties of the Corps of Engineers was confronted with peculiar difficulties growing out of the war. The two organizations which had existed since 1838 had been consolidated into a single corps during its progress, and casualties among the personnel had been severe. Many young officers had joined during the war, and had risen to high rank with little or no experience except with armies in the field. But Congress immediately inaugurated works of internal improvement upon a larger scale than ever before, and of a character to demand high professional skill in their inception and execution. The corps was thus suddenly called upon to bear the responsibility of projecting and constructing a system of water communications and of river and harbor improvements over an area but little less than that of the whole continent of Europe, while the surveys of the Great Lakes and of the Western Territories were still actively prosecuted. This responsibility was met by the chief in a manner which illustrated his good judgment and knowledge of men, and which produced excellent results.

The more experienced officers were placed on boards to project works at important localities, and in their individual capacities to supervise the constructions and disbursements throughout extensive districts. The younger officers were assigned as assistants to exercise local supervision and make themselves familiar with both theory and practice by special reading and experience in the field. Very soon the whole force was organized and working together as a unit to carry into effect the legislation of Congress. Whatever success may have attended the operations of the corps at this important period of its history deserves to be associated with the chief who directed its labors with a skill for which his own studies had been so admirable a preparation.

Upon his own application, at the ripe age of 68 years, General Humphreys' name was transferred to the retired list of the army. Fifty-two of these years had been devoted to the service of his country. He had performed an amount of mental labor of which few men are capable, but his eye was undimmed and his brain was as clear as ever. Repose was far from his thoughts. He was an enthusiastic soldier, and the responsible positions he had held as Chief of Staff and Corps Commander in the Army of the Potomac had made him more familiar with its campaigns than any other man then living. It was his purpose to prepare a history covering the period after he became Chief of Staff in the summer of 1863. The Scribner's Series, to which he was invited to contribute, afforded him the opportunity, and he at once undertook the labor. It would have been easy for him to prepare a volume of personal recollections, but that was not his method of doing work. The official records of both armies had been so classified and arranged in the War Department as to afford authentic material for history in the true sense of the word, and he applied himself to the task of its analysis with the energy of youth and the ripened judgment of a man familiar with affairs. The condensed form of the publication hampered and restricted him, but the result in two small volumes is worthy of a place by the side of Cæsar's Commentaries and of Zenophon's Anabasis. They will remain with military men the touchstone for judging of the accuracy of more extended histories of these campaigns.

General Humphreys' individual contributions to science were appreciated both in this country and in Europe. In 1857 he was elected a member of the American Philosophical Society; in 1862, an honorary member of the Imperial Royal Geological Institute of Vienna; in 1863, a fellow of the American Academy of Arts and Sciences. In the same year he became one of the original corporators of the National Academy of Sciences. In 1864 he was elected an honorary member of the Royal Institute of Science and Arts of Lombardy. The degree of LL. D. was conferred upon him by Harvard College in 1868. He was also a corresponding member of the Geographical Society of Paris, of the Austrian Society of Engineer Architects, and of the New Orleans Academy of Sciences. In 1880 he was elected an honorary member of the Italian Geological Society. In March, 1885 (after his decease), notification of his election as a corresponding member of the Geographical Society of Hungary was received.

His military honors were equally distinguished. He received the brevet of colonel in the regular army for gallant and meritorious services in the battle of Fredericksburg, Virginia, of brigadier general for gallant and meritorious services in the battle of Gettysburg, Pennsylvania, and of major general for gallant and meritorious services in the battle of Sailor's creek, Virginia, in which he commanded the Second Army Corps.

In contemplating such a career it is natural to search for the secret of its success. A little incident which occurred before the war goes far to reveal it. One day, when studying a report that bore evident marks of neglect and ignorance of its subject, he suddenly brought his clenched fist heavily upon the table, exclaiming: "I cannot understand how any man can be willing to assume charge of a work without making it his business to know everything about it from A to Izzard." These words unconsciously sounded the keynote of his whole life.

In official relations General Humphreys was dignified, self-possessed, and courteous. His decisions were based on full consideration of the subject, and once rendered were final. He had a profound contempt for everything which resembled double-dealing or cowardice. He scorned the arts of time servers and demagogues, and when confronted with meanness took no pains to conceal his indignation, no matter what might be the rank or position of the offender. He felt the warmest personal interest in the success of his young associates, and often did acts of kindness of which they learned the results but not the source.

In his social relations General Humphreys exerted a personal magnetism which can hardly be expressed in words. His manners were marked by all the graceful courtesy of the old school, while the unaffected simplicity and modesty of his character and the force and vigor of his ideas left an impression not easily effaced. He was a gentleman by nature, not merely by artificial polish, and no one could be thrown much in his society without recognizing the fact.

Friends privileged to meet him intimately in his own house could not fail to be charmed with the atmosphere of love and happiness which pervaded the home circle. In 1839 he married his cousin, Miss Rebecca Hollingsworth; and in her society, surrounded by his sons and daughters, he threw off the burden of care and became the genial companion and kind-hearted friend.

He was fond of music and literature, and all his tastes were cultivated and refined.

On the evening of December 27, 1883, General Humphreys passed from life as he would have wished, seated alone at his table. The family had retired, bidding him good night apparently in his usual health. Full of years and honors, his life work well done, most admired and beloved by those who knew him best, one of the great men of our age and country there rested from his labors, leaving in many hearts a void which will never be filled.

MEMOIR

OF

JOHN LAWRENCE SMITH.

1818-1883.

BY

BENJAMIN SILLIMAN.

READ BEFORE THE NATIONAL ACADEMY, APRIL 17, 1884.

BIOGRAPHICAL MEMOIR OF JOHN LAWRENCE SMITH.

THE Academy mourns the death in the past year of Alexander, Guyot, Engelmann, Humphreys, John L. LeConte, Norton, and Smith.

The sad but grateful duty has been assigned to the writer to speak of the life and labors of Smith, with whom he had the happiness to maintain an uninterrupted and life-long friendship.

JOHN LAWRENCE SMITH

was born near the city of Charleston, South Carolina, December 17th, 1818, where he received the best training offered by the private schools of that city. "Even as a child of four years, and before he could read," says his friend, Dr. Marvin, "he was familiar with the operations of simple arithmetic; at eight he was prepared for the study of algebra, and at thirteen was studying the calculus." This mathematical taste he retained through life, although circumstances later led him into different paths. His taste for physical phenomena and for scientific pursuits led him to elect at the University of Virginia, where we find him before he was yet seventeen years of age, the branches of chemistry, natural philosophy, and civil engineering, to which he devoted two years. Chemistry he followed under Prof. John P. Emmet, natural philosophy under Prof. William B. Rogers, civil engineering and mathematics under Prof. Chas. Bonnycastle.

By the plan of study adopted at the University of Virginia at that time the subject of civil engineering was divided under eight distinct heads between the professors of mathematics and natural philosophy, viz: I. Graphical mathematics. II. Theory of levelling and surveying. III. Theory of roads, railroads, canals, and bridges. IV. Theoretical mechanics, hydrostatics, hydrodynamics, &c. V. Laws of heat, steam, and steam-engine. VI. Geology and mineralogy. VII. Field practice in surveying. VIII. Plan drawing, plotting, topographical plans, &c. The six first named were divided between the chairs of physics and mathematics.

Such were the subjects to which Smith devoted the two years of his life at the University of Virginia, and under the stimulus of such teachers as Emmet, Bonnycastle, and Rogers we cannot doubt that his early preference for these studies was deepened and confirmed.

The writer now recalls the vivid impression made upon his own mind by a lecture which he heard from Mr. W. B. Rogers, in the autumn of the year 1836, at the University of Virginia, on the Resultant of Forces. It was in that year Smith entered this university, and there is no evidence that he attended any of the classical or literary courses of the institution. Whatever attention he bestowed on literary studies must have been in his preparatory schools in Charleston.

The year immediately following his residence at the University of Virginia he devoted to the duties of assistant engineer upon the railroad line between Charleston and Cincinnati. This pursuit proved to be uncongenial to his taste, and was abandoned for the study of medicine.

The Medical College of the State of South Carolina was at that time distinguished by the presence of a very able body of teachers, and here Smith took his medical degree in 1840, submitting as his graduation thesis an essay upon the "Compound Nature of Nitrogen."[1]

The now venerable Professor Chas. Upham Shepard, who was Smith's chemical teacher, at Charleston, in his medical course, in reply to my inquiry respecting Smith's early life, writes as follows, March 4, 1884:

"I regret not being able to furnish you with the particulars you desire concerning the life of Dr. J. Lawrence Smith farther than that he was a diligent student of our Medical College, especially in the department of chemistry, and that on graduation he submitted a very ingenious thesis, entitled '*The Compound Nature of Nitrogen.*' He was known to be very fond of chemistry, but I am inclined to believe that his time was chiefly devoted to other branches of the medical profession, as he was then looking forward to the practice of medicine in his native city. I think it possible, however, that

[1] A silver goblet, still in the possession of Mrs. Smith, was presented to Dr. Smith in honor of this thesis by the Faculty of the Medical College of the State of South Carolina, 1840.

his taste for mineralogy may have been promoted at this period of his career.

"After finishing his studies in Europe and commencing practice here he gave a course of lectures on toxicology before our students, which was highly approved. He was then much occupied with chemical analysis of the limestones, marls, and soils of this vicinity, and contributed valuable results to the agricultural journals of this place.

"His leading aim at simplifying processes in analysis was most apparent—a field in which he afterwards achieved his chief distinction."

Dr. Smith's father was a merchant in Charleston of sufficient fortune to enable his son to prosecute his studies beyond the curriculum of the medical school of his native city. Immediately after taking his medical degree, therefore, Smith went to Paris to follow the most distinguished teachers in medicine and other departments of science. With Dumas he followed chemistry pure and applied, and with Orfila toxicology; with Poulliet, Desprez, and Ed. Becquerel he followed physics, and with Dufrenoy and Elie de Beaumont mineralogy and geology.

During one of his summer excursions he found himself at the door of Liebig's laboratory at Giessen. This accidental circumstance turned the whole course of his life into the channel from which it was never afterwards diverted.

He became a zealous and enthusiastic student of chemistry under the inspiration of Liebig. He appears to have divided his time between Giessen in the summer and Paris in the winter. This result was foreshadowed, as we have seen by his early tastes.

While yet a student in Charleston, South Carolina, his maiden communication to the American Journal of Science was on "Chromate of Potassa—a reagent for distinguishing between the salts of baryta and strontia."[1]

In this paper he first made known to chemists this very delicate and now very familiar test for baryta, and determined its quantitative value. This paper is interesting as the first evidence of Smith's acumen in devising new analytic methods in chemistry. In the same year he published a second paper—"On a new method of making permanent artificial magnets by galvanism."[2]

[1] Am. Jour., [i] xxxvi, 183. 1839.

[2] Am. Jour., xxxvi, 335. 1839.

Soon after his arrival in Paris Dr. Smith opened a correspondence with the writer, which continued during life.

In 1842 he thus transmitted to the American Journal of Science his first important chemical research on "The composition and products of distillation of spermaceti, &c."[1] This paper is dated Paris, April 29, 1842. It is an elaborate research, embracing many ultimate organic analyses from which the true composition of spermaceti was first made known. He set aside the views of Chevereul—that spermaceti was a fat, and reached the conclusion that it was a compound of ethal, and that by its distillation a molecule of ethalic hydrate and cetine was produced.

Organic chemistry was at that time without the powerful aid of a comprehensive classification, and the theory of the compound ethers had not been developed; otherwise the work which Smith accomplished so well would have led him to the conclusion that spermaceti was *cetyl palmitate* (cetine)—a view with which his analytical results accurately corresponded.

At the time when this research was made probably no American chemist had done any work in organic chemistry of so elaborate a character as we find in this investigation. This paper was reproduced in the *Annales de Ch. et Phys.* of Paris, in *Liebig's Annalen*, in *Sturgeon's Journal*, and in *Majocchi's Jour. Fis.*, &c.

In a subsequent paper on the action of potash on cholestrine[2] he shows that this body, usually considered by physiologists as a fat, was, in reality, as then judged, nearly related to spermaceti. This paper, he states, was intended as an appendix to his more elaborate research upon spermaceti.

Shortly after Dr. Smith reached Paris he found the whole of France agitated by one of the most interesting criminal processes upon record—that of Madame La Farge. This case involved the question of the normal existence of arsenic in the human body, and of its presence in hydrated peroxide of iron, used as an antidote. Dr. Smith reviews these and other questions in a paper entitled "On the means of detecting arsenic in the animal body, and of counteracting its effects."[3] The date of the paper is Paris, December 6th, 1840. He was then a student of Orfila, but he does not

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[1] Am. Jour., [i] xliii, 301.

[2] Am. Jour. Sci., [i] xliv. 1843.

[3] Am. Jour. Sci., [i] xl, 278–293. 1841.

hesitate to expose the errors of his distinguished professor in this celebrated case—errors afterward acknowledged by Orfila himself.

He follows up this subject by a second paper of date June 28th, 1841, entitled "Continuation of remarks made upon arsenic, considered in a medico-legal point of view,"[1] in which he described the method of Danger and Flandin for destroying animal matter in toxical examinations, and also the then new form of Marsh's apparatus; and he still further reviews the ground for rejecting the opinion that arsenic is ever a normal constituent of the animal body, supporting his statements by evidence from his own original work.

We have already alluded to Dr. Smith's arrival, in the summer of 1841, at the laboratory of Liebig at Giessen. In November of that year he sent to this country from Giessen a translation of Will and Varrentrapp's method of determining nitrogen in organic compounds, then unknown in this country, accompanying it with notes of his own. This paper he supplemented in 1843, after his return to this country, with a notice of M. Reizet's criticisms upon the limits of accuracy of this method.[2]

It is pretty evident, from his scientific work while in Paris, that the study of medicine was subordinate to his interest in chemical research, and we are, therefore, prepared to find, after his return to this country, that medical practice offered few attractions for him. He indeed commenced practice, but found time to prepare and deliver courses of lectures, like that already mentioned by Prof. Shepard, before the Medical College on toxicology.

He also, in 1846, inaugurated the Medical and Surgical Journal of South Carolina, associated with Dr. Sinclair. He remained in this editorial work only one year before he went to Turkey. Before this time he had done some important work in chemical analysis and in the improvement of analytical methods; thus determining the action of alkaline salts on sulphate of lead; the composition of fossil bones from near Charleston, and the origin of the fluorine found in them; the action of solutions of the neutral phosphates upon carbonate of lime, and the composition of marl from Ashly River, South Carolina. A summary of these researches is contained in a paper published in October, 1844.[3]

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[1] Am. Jour. Sci., [i] xlii, 75–81. 1842.

[2] Am. Jour. Sci., [i] xlv, 267. 1843.

[3] Am. Jour. Sci., [i] xlviii, 97–104.

He also turned his attention to the operations of the high iron furnace in two papers on this subject, and contributed abstracts of the researches of European chemists to the American Journal of Science (1845).[1]

These papers on agricultural chemistry—the composition of soils, the value of the marls and fossil bones of the Ashly River, &c.—undoubtedly led to his selection by Secretary (later President) Buchanan as a suitable person to meet the call from the Sultan of Turkey for scientific aid in introducing into that kingdom American methods in the culture of cotton—a subject with which he was also familiar.

This appointment marks an important epoch in Smith's career. It opened to him a new and virgin field of research, and offered him an opportunity to use his acquirements in a way different, indeed, from his expectations, but not the less important, Finding, on his arrival in Turkey, that an associate proposed to inaugurate the cultivation of cotton on a plan doomed to failure, he was about returning to America, when he received from the Turkish government a commission to explore her mineral resources. He entered at once, with his customary zeal and intelligence, upon this work, and in the four years of his residence in the Sultan's dominions, in spite of many vexatious restrictions, he opened up natural resources which have ever since added an important item to the revenues of the Porte.

His memoir on emery was equally important, both from a scientific and economic stand-point. Before his observations "On the geology and mineralogy of emery, made in Asia Minor," little was known of the mode of occurrence of this useful mineral. The Island of Naxos had long been almost the only locality, and the supply from this source was limited and the price excessive, and no geologist had found an opportunity of studying the mineral associations of emery or its relations to corundum. Smith's sagacity as an observer; his originality in discussing new methods of examination; his patience and conscientious fidelity in executing his work, are all conspicuous to the student of this memoir. From the study of the mineralogical associations in which he found the emery of Asia Minor he felt convinced that the search for like associations elsewhere would be rewarded by the discovery of emery or corundum.

[1] Some of his work at this time is found in the Reports of Tuomey on the Geological Survey of South Carolina, *q. v.*

With this view he addressed the present writer, requesting him to test the correctness of his observations upon known localities of corundum in the United States. The associate minerals were immediately found and reported. Later on, after his return to America, Smith had the opportunity of seeing the accuracy of his views demonstrated at the emery mine of Chester, in Hampden county, Massachusetts, which Dr. Charles T. Jackson had discovered by use of the key of its associate minerals, as suggested by Smith, the locality having been before regarded only as an iron mine. This mine is the subject of a special memoir by Smith, which will be found, pp. 42–53 of his volume of memoirs, 1873.[1]

Dr. Smith's memoir on the Turkish emery was presented to the French Academy in 1850, and was, at the recommendation of a special commission, of which Dufrenoy was the reporter, ordered to be inserted in the "*Recueil du Mémoires des Savantes Etrangers.*" It will also be found in the American Journal.[2]

In a letter to the writer, dated Paris, September 3d, 1850, Smith says he sends by a private hand the full translation of the first part of his paper on emery, and suggests, if no time is lost in its publication, it would first appear in full in America. It was, in fact, published simultaneously. He adds: "The second part I think you will like better than the first, and I shall set to work to translate it immediately. Please correct any little Gallicisms that you may find in the paper."

This last injunction is a tacit acknowledgment of the fact that the French idioms had a strong hold upon his literary style. We all were quite accustomed to this peculiarity, and found it not always easy to correct all the "little Gallicisms" without an almost new translation.

"I am now engaged," he adds in the same letter, "on the urinary calculi of the Museum of Dupuytren. This will be finished in about ten days. I shall then complete some odds and ends that I have in hand and leave for home about the first of October (1850). I shall give you more matter for the journal next year than you want from

[1] Mineralogy and Chemistry. Original researches by Prof. J. Lawrence Smith, of Louisville. 8vo, p. 401. 1873. A new edition of this volume of memoirs is now in course of printing by Dr. J. B. Marvin, of Louisville, which will contain a more complete collection of Dr. Smith's papers, brought down to the date of his death.

[2] [2], vol. x, 354–369.

any one indvidual. I did not visit your annual association, as much from diffidence as anything else."

His results on the urinary calculi above alluded to, I suspect, were never published, and he never carried out his purpose to describe his methods of analysis devised for this research. I only learn incidentally from a subsequent letter that two hundred calculi were examined.

Many other researches, scientific and economic, on coal, chromite, magnesite, &c., were prosecuted by Dr. Smith while in the service of the Ottoman government, several of which will be found in the volume cited, to which reference must be had for details. Of these his memoirs on thermal waters of Asia Minor is too important to be passed without mention (1849).[1]

Very soon after the Morse system of telegraphy was developed in the United States Smith applied to the present writer to send him as complete an apparatus as could then be had, with conductors sufficient to connect the Sultan's palace at Constantinople with the Bosphorus, and when all was ready the Sultan was invited to witness the operation of the first electric telegraph erected in his dominions, and was moved, as a consequence of the unselfish advice of our friend, to confer upon Prof. Morse a high decoration in recognition of his important invention. The Sultan was so impressed with the value of Dr. Smith's services in developing the resources of his dominions that he conferred on him substantial favors and honorable decorations in recognition of his esteem and friendship. He found his residence in the Sultan's dominions by no means agreeable to a man of his active temperament and to one impatient of diplomatic restraint. In a letter dated June 6, 1848, he says:

"And what do you think of my proposed plan of returning to America? Here I feel like a caged bird, being prevented from making those examinations of the country that my situation would so well enable me to do. But no! they must keep me at Constantinople the most of the time, because they *might want me*, and when I do go it is always with a troop of lazy, ignorant scoundrels, who are sent rather to watch my movements than to afford any assistance. The people are both suspicious and ignorant, and they believe an honest man exists only in the wildest dreams of philosophers. My last discovery was that of chromate of iron near

[1] Comptes Rendus du seances, de l'Academie des Sciences. Oct. 28, 1850.

Broussia. Nature, in placing all these mineral riches here, only threw 'pearls before swine.'"

In a former letter (May 27th) he says:

"I am becoming more and more disgusted with this country and its people, and have my hands tied by their stupidity and ignorance. You must recollect the coal mine I discovered about a year and a half ago, of which I made a detailed report to the government, giving the best manner of working it, &c. To this they appeared to pay great attention, and a few months ago got out a collier from England for the purpose of commencing the working of it. No sooner are all the preparations made than the government says it must not be worked; and why? Because the Sultan's mother and some of the great Pachas do not wish it, they owning mines on the Black Sea. This is done when there are hundreds of thousands of tons of coal brought from England every year. Comments are useless. They fear to go to the slightest expense in opening a new mine; consequently their great mineral treasures are useless to them."

Mention has already been made of Dr. Smith's very liberal and unselfish efforts to secure a proper recognition of the services of Prof. Morse in telegraphy. In his letter of November 7th, 1849, he says:

"You make allusion to Prof. Morse's decoration, about which I do not know that I have said anything to you. The fact is, I did not know that it had reached him until four or five months ago, when I came across an old American newspaper speaking of Prof. Morse's magnificent diamond broach. I do not know that you are aware that it was from a wish upon my part that the decoration was sent to Prof. Morse. The sole honor I expected to have in the matter was to transmit the decoration to him as the Sultan had ordered. But our minister thought proper to do otherwise, and, after a very long delay, he forwarded it himself. The fact is, after the decoration was accorded to Morse it would not have been given, had I not pushed the matter and proved, in a document sent to the Minister of Foreign Affairs, that Prof. Morse was entitled to the invention, that some English intriguers here wished to deprive him of. However, I send you a note written to me some time ago by the dragoman of the legation, who is the only one beside myself who is acquainted with the whole affair.

"Excuse me for writing to you about an affair which turned a loss to me without my obtaining the little honor that I coveted—that of exhibiting my esteem for the merits of Prof. Morse." * * *

He concludes this letter thus:

"I have been trying for some time past to conclude my arrangements with the Turks, and have at last succeeded. To remain here any longer is very much against my wishes, for my occupations interest me but little, and are of no general utility. Could I travel about as I wish, I could remain here ten years.

"In leaving his service the Sultan has thought proper to express his satisfaction at the service I have rendered him, and to present me with an elegant gold snuff-box set with diamonds. He has also ordered an official expression of the satisfaction of government to be given to me by the grand vizier, &c. So ends my career in Turkey. I leave in a day or two for Syria and Egypt, and after visiting these countries shall return to America by way of France."

Notwithstanding Dr. Smith's regrets over the folly of the Turks in hampering his movements, and so limiting his discoveries and researches, the fact remains that he managed, in spite of annoying restrictions, to reap a rich harvest of good work in the Ottoman Empire, at the record of a part only of which we have glanced.

He reached Paris in the early spring of 1850, and remained there until the following October, occupied with scientific work relating chiefly to the researches on emery and its associate minerals, and the presentation of his two memoirs on this subject to the Institut. He also found time to project his inverted microscope, which he matured after his return to America.

We have seen also that he took in hand the analysis of the urinary calculi of the Musée Dupreytren.

Many matters of chiefly mineralogical interest are found in his letters written during this period, but as the facts have long since found their proper place in the records of science, the letters now possess only a personal and historic interest.

After his return from his Turkish and European residence Dr. Smith passed almost immediately to New Orleans, where he remained about two years, having accepted an invitation to deliver courses of lectures on science before a lyceum or scientific society.

While there he was also elected to a chair in the scientific depart-

ment of the University of New Orleans, "which," he writes, in December, 1850, "at present exists but in name." Nevertheless we find at the head of his papers, prepared at this time, he uses the title of professor of chemistry in the University of Louisiana. Here he completed researches commenced abroad, as, for example, the description of the inverted microscope,[1] of which I find a pretty full notice in a private letter, with a figure, of date December 21, 1850, within a month after his arrival in New Orleans. Here he felt keenly, and deplores, the want of a laboratory as greatly hampering his researches. But he found occupation in a variety of work which he could accomplish with the limited means at hand, and I find him, in January, 1851, projecting an excursion to Arkansas, up the Mississippi to Missouri, and to Kentucky. This plan he carried out later. In a letter of October 9th, 1851, from Charleston, where he then was on a visit, he expresses his regrets that he had not yet a permanent place of residence. "I often regret," he says, "that I am not more permanently established, for my concentration on scientific labor can never be made advantageous until I have a well-mounted laboratory of my own. All my scientific labors have as yet been carried on in the Gipsey style. * * * In fact I have been literally a sort of peripatetic philosopher, carrying my own hammer and anvil and doing a little wherever I could get a place to work in. It would no doubt surprise you to see in my baggage a box of platinum, from a pint capacity down; bottles of pure carbonate soda, bisulphate of soda, fluor-spar, potash, carbonate of lime, &c.; in fact, my essentials that I am only satisfied of as to purity when they come from my own stock."

This habit of keeping a stock of pure chemical reagents in his baggage he retained for a long time, even after he was permanently settled in Louisville.

In 1852, June 24th, he married a daughter of the Hon. James Guthrie, of Louisville. This happy marriage decided the future course of his life. Cheered and sustained by the genial companionship of a wise and devoted wife, who took an intelligent interest in his pursuits, and was his constant companion during his frequent journeys at home and abroad, under her influence we find the opening out of a side of Dr. Smith's character which in his migratory life had little opportunity for expression. His tender human nature

[1] Am. Jour. Sci., [2] xiv, 233. Sept., 1852.

now found opportunity for development in works of charity and religion and in graceful hospitality. Louisville was destined hereafter to be his home, but not immediately. He was turning his mind toward the chemical chair in the University of Virginia, lately vacated by the transfer of Dr. Robert E. Rogers to Philadelphia, and to this place he succeeded in the autumn of 1852. He held this chair for only one year, but it was a year of great scientific activity, in which, aided by the efficient assistance of Mr. Brush, he was able to accomplish a very important amount of original investigation in the department of chemical mineralogy and in perfecting his new method of analyzing the alkaline silicates.

This subject had engaged his attention before he left Paris, but it was only after commencing work at the University of Virginia that he put it in form for publication.

In a letter, of date January 7, 1853, addressed to the writer at Louisville, after passing an encomium upon Brush, he adds:

"My method of analyzing the alkaline silicates is now complete, and will appear in the next number of the journal. This method of decomposing silicates for the alkalies is quite as easy as a carbonate of soda fusion, which latter, however, is an insignificant decomposing agent along side of it. Zircon and kyanite yield to it at a light red heat in an open furnace. Carbonate of lime is the agent. You will learn how to use it for this purpose by referring to the forthcoming paper."

This paper, which appeared in March, 1853,[1] was a very valuable contribution to analytical methods, and Smith's process for decomposing the alkaline silicates, by the use of calcium carbonate and chloride, is now the generally accepted method.

The researches on American minerals, carried on jointly by Smith and Brush, were made in 1853, and have long since passed into the records of science. They settled many doubtful points, and relegated into obscurity many worthless species, while clearly establishing others.

It may be asked why so prosperous a commencement of professional life at the University of Virginia should not have been continued beyond the period of one year? At this time Mrs. Smith's

[1] Am. Jour. Sci., [2] xv, 234–243. Completed in Part II, July 1, 1853. [2] xvi, 53–61.

father, the Hon. James Guthrie, was Secretary of the Treasury of the United States, residing at Washington, and it was no doubt his wish to reunite his family in that city, which was largely instrumental in deciding Dr. Smith's resignation at the close of his first year at Charlottesville.

The Smithsonian Institution offered him a convenient and agreeable place for prosecuting his researches, and there he spent the following winter, as well as several subsequent summers; and while there he also worked in the department of agricultural chemistry for the United States Department of Agriculture. I am favored by Prof. F. H. Smith, of the physical chair at the University of Virginia, who was there when Dr. J. Lawrence Smith commenced his labors, with an interesting reply to my inquiry as to Dr. Smith's success as a teacher. He says, in a letter of date March 12, 1884:

"His course of lectures were remarkable in several particulars—

"1st. The freshness and thoroughness of his chemical knowledge as given to the class. He appeared fully abreast and even in advance of the general status of the science. He spoke as a master. His experiments were often novel and, I believe, generally successful, as well as striking, partly owing to the efficient aid he had from George J. Brush, now professor at Yale College, but then his private assistant and student.

"2d. The fact that he confined his lectures to chemistry proper, leaving physics to the professor in charge of that branch. This he did, I believe, of set purpose, with the result of his giving more chemistry in eight months than his predecessors had done, nominally, in nine, but really in six.

"3d. The awkwardness and unrhetorical form of his address, and his inattention to, if not contempt for, all mere graces of style, and this in an institution where the graces of style were greatly valued, as evinced in the shining example of William B. Rogers, John B. Minor, John Stager Davis, and others. The contrast was a matter of general comment. But I am not sure that, in the end, it at all diminished the instructiveness of Dr. Smith's teachings, and did not, in fact, increase the impression they made. I heard one or two of his lectures myself, and certainly had no feeling but one of admiration for the excellence of his treatment of his theme and the admirable experiments with which he illustrated it.

"As a man he impressed me as one of thorough, conscientious loyalty to truth and duty. I have never met him since without a feeling of pleasure, based upon profound respect for him personally as well as professionally."

In 1854 Dr. Smith accepted the chair of medical chemistry and toxicology in the University of Louisville, then made vacant by the resignation of the writer. This chair was retained by Dr. Smith until the spring of 1866, when he resigned. Possessed now of an ample fortune, and frequently called, in the way of his profession, to visit Europe, he found the restraints of a professorship in an institution no longer prosperous, distasteful, and naturally preferred to devote himself to the more congenial researches which he had recently commenced in the department of aerolites, to the collection and study of which he gave great attention during the remainder of his life. His first memoir on this subject was his description of five new meteoric irons in 1854, forming part of his memoir on meteorites, read before the American Association for the Advancement of Science in April, 1854, at Washington, but not published until the following year.[1]

This memoir is also reproduced in his volume of Scientific Researches. In this paper Dr. Smith appears for the first time as the author of a general theoretical discussion of cosmical or astronomical considerations as to the origin of meteorites. His views are expressed with force and clearness. He antagonizes the notion that meteorites, as we know them from fragments which reach the earth, are large, solid cosmical bodies, passing through the earth's atmosphere with planetary velocity, and dropping small portions of their mass in their flight. He advocates strongly the lunar origin of meteorites as the most probable theory yet advanced. This view he sustains with the courage of his convictions, and illustrates by citing many interesting facts, which, in his view, go far to establish the lunar theory. It is not now the time to follow this discussion, but it is interesting to note the fact that, from the time Smith took up the discussion of this subject, the study of meteorites became almost the exclusive theme which occupied his attention. Thus, if we turn to the list of his papers in the Royal Society catalogue, we find, out of seventy-eight titles, down to 1873, there are twenty-two upon

[1] Am. Jour. Sci., [2], xix, 153–332.

meteoric subjects, all subsequent to 1854, and of these seventeen papers were printed between 1864 and 1873, the date of the publication of his volume of papers already cited, and in this volume of four hundred pages one hundred are devoted to meteorites. In the ten years succeeding there are seventeen additional meteoric papers and many on other subjects, chiefly mineralogical. The list of Dr. Smith's papers appended to this notice of his life embraces the full titles.

The last paper printed by Dr. Smith, in the June issue of the American Journal of Sciences, 1883, was "On the peculiar concretions in meteoric iron." At the close of this paper he says he shall continue the research, "if," he adds, "my health permits." It was his last work.

Dr. Smith's collection of meteorites was commenced by his purchase of the collection of the late Dr. G. Troost, of Nashville University, who was fortunate in securing a number of large iron meteorites from Tennessee, but Smith added constantly to this collection from all parts of the world, and especially of irons from Mexico, as well as from the United States, and of stones from such falls as those of New Concord, Ohio, in May, 1860, and from the great fall of Iowa in February, 1875; Nash county, North Carolina, 1872; Warren county, Missouri, January 7, 1877, and others. He sold a number of his larger iron masses in 1862 to Prof. C. U. Shepard in London, and of the Mexican irons to the museum of the Garden of Plants in Paris (1879).

Fortunately for science this fine meteoric collection has passed entire, by purchase, into the possession of Harvard College. It is a memorable circumstance that the news of the completion of this sale was communicated by telegraph to our lamented associate, greatly to his joy, on the last day of his life! It was Dr. Smith's ardent wish that his collection should be kept together, and having failed in accomplishing this object with a local institution, in the permanency of which he had lost confidence, he was only too happy to contemplate its secure position in the cabinet at Harvard College.

Prior to 1862 it had been less an object with Dr. Smith to amass a large collection of meteorites than to use those he had already described, as a means of procuring others, which were new to science. Hence his collection has been largely gathered since that date, after which time he decided to make his collection as complete as possible.

Prof. Cooke, of Harvard, informs me that the Smith collection

represents about two hundred and fifty falls, and a total weight of about twenty-five hundred pounds, making the Harvard collection, including what they had before, represent in all about two hundred and seventy falls.

In the British Museum there are now represented about three hundred and fifty falls, and in the Garden of Plants, now second only to the British Museum, a few over three hundred falls. The Harvard-Smith collection will soon be commemorated in a complete catalogue. This collection is inferior to that of London and Paris in the number of stones, but is said to be quite equal to that of the British Museum in the irons.

It will be interesting to see a complete catalogue of all the meteoric collections in the United States, some of which exceed the Harvard collection in the weight, if not in the number, of falls reported.

Dr. Smith's collection is, in a sense, a monumental one, memorial of the life-work of a devoted student in this very interesting department of cosmical chemistry and mineralogy.

Dr. Smith was in 1872 elected a member of this Academy, and in 1879 corresponding member of the Academy of Sciences of the Institut of France, succeeding Sir Charles Lyell. Few Americans have received more academic honors, abroad and at home, than Dr. Smith.[1] He was chevalier of the Legion d'Honneur, and in 1874 was president of the American Association for the Advancement of Science.

Although Dr. Smith felt at home in Louisville, where his family ties and numerous friendships bound him and where he preferred to remain, he was at the same time isolated in all his scientific work. He had built an ample house, where he was surrounded with the interesting memorials of a lifetime, and in which he also provided space and accommodations for his private laboratory on the upper floors, where he could pursue his researches uninterrupted.

He acted as commissioner at the Paris exposition of 1867, and prepared the report on the chemical industries, entitled "The progress and condition of several departments of industrial chemistry." This document formed part of volume II of the official reports of the United States commissioners, published at Washington in 1869 in six volumes and edited by W. P. Blake. Dr. Smith

[1] A full list of his memberships and decorations is appended.

served in the same capacity at the Vienna exposition in 1873. I have never seen his report of the work done there. I know that he prepared an elaborate report on the petroleum production and industry of the United States, for which I furnished him material, but I understand this was sent to Dr. Hofmann, and was published in German, but has not been reproduced in English.[1]

It was in 1873 that Dr. Smith went to St. Petersburg with Prof. Daubrée to attend the centennial of the Chemical Society, and in 1879 he again spent a year in Europe, with his wife, visiting Sweden and Norway, going as far as the North Cape, and there celebrating the Fourth of July under the midnight sun.

His elaborate paper on the so-called meteoric irons of Greenland and the basalts was presented to the Institut of France in 1879, and is published at length in the *Comptes Rendus* of that year. The title is given in the list of his papers appended to this notice.

Unfortunately, many of Dr. Smith's valuable notes and manuscripts were burnt in transit from Charleston to the University of Virginia in 1853, and he was always too much occupied with new work to reproduce them.

His fondness for practical work led him to accept the charge of the gas-works at Louisville, for which he acted as president for several years. He also established a laboratory for the production of chemical reagents and of the rarer pharmaceutical preparations, in which enterprise he associated himself with Dr. E. R. Squibb, whose fame as a successful worker in pharmaceutical chemistry is well known.

In reply to my inquiry, Dr. Squibb wrote me a letter, from which the following sentence is extracted, which is interesting as shedding light upon a side of Dr. Smith's character which is little known:

"During the year and a half that I was there so closely associated with him I learned to respect and esteem him more highly than ever before, and have always regretted that after we separated I could see so little of him. For many years, however, he made me annual visits, usually spending most of the day in looking into mechanical devices and adaptations, in which he was always very much interested.

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[1] I have failed to secure a copy of this memoir, the title of which I am, therefore, unable to add to the list of Smith's papers. B. S.

"He was a man of great ability and of great integrity of character."

Dr. Smith's personal character possessed a charm which won all who came within the sunshine of his genial nature. His sturdy manliness and integrity was combined with an almost feminine gentleness.

During the years of the civil war, while his affiliations and lifelong associations were inseparably united with his native South, he deplored the sad conflict with a spirit bowed as under a personal sorrow. I never heard a word from him on the subject which partook of bitterness or animosity, and no shadow passed across the path of his old friendships.

He had no children, but he had founded an orphan home in Louisville, and amply endowed it in connection with the Baptist denomination, of which he was for many years a devoted member.

For two or three years before the end of his life he had been in delicate health from a chronic affection of the liver. He was seldom confined to his house, but on the first of August, 1883, a severe attack of the disease compelled him to take to his bed, from which he never arose again. Without acute suffering he passed peacefully away on Friday, October 12th, at three in the afternoon.

By his directions his funeral was of the most simple character, and without an eulogy. His life closed as he had lived, peacefully, with uncomplaining endurance of suffering. His last words were: "Life has been very sweet to me; it comforts me. How I pity those to whom memory brings no pleasure."

He was warmly attached to the National Academy of Sciences, and was always in full sympathy with its objects and with his fellow members. His memory is dear to us, and we rejoice that though dead he yet lives, and that the work he loved so well will be perpetuated, under the auspices of the Academy, by a noble endowment bestowed *in memoriam* by his devoted wife.

Sic itur ad astra!

NOTE, JULY 1ST, 1884.—The endowment mentioned in the closing sentence of the foregoing notice has been completed by a deed of trust from Mrs. Dr. Smith, conveying to the National Academy of Sciences the sum of $8,000 as a fund, the interest of which is to promote, by original investigation, the study of meteoric bodies, to which a large part of Dr. Smith's life was successfully devoted. At the discretion of the Academy a gold medal, of the value of $200, is to be awarded, not oftener than once in two years, to the person, of whatever nationality, who, within the previous two years, has made the most important advances in this line of investigation; or the income may, if the Academy so decide, be awarded from time to time in aid of such researches, but in this case only to citizens of the United States. The dies for this medal, by the celebrated artist CHAPLAIN, of Paris, are also provided by Mrs. Smith at her own expense. The medal will carry on the obverse the head of Dr. Smith in profile, the bust in a classic toga, and on the reverse the legend in Latin—*J. Lawrence Smith medal for researches in meteoric bodies*, with the name of the Academy and of the person to whom it is awarded.

It is interesting to know that this fund represents the sum paid by Harvard College for the meteoric collection of Dr. Smith, the purchase of which by that institution is mentioned in the foregoing notice.

B. S.

JOHN LAWRENCE SMITH, M. D.,

Member of the American National Academy of Sciences; Membre correspondant de l'Institut de France (Academie des Sciences); Member of the Chemical Society of Berlin; of the Chemical Society of Paris; of the Chemical Society of London; of the Société d'Encouragement pour l'Industrie Nationale; of the Imperial Mineralogical Society of St. Petersburg. Corresponding Member of the Boston Society of Natural History; of the American Academy of Arts and Sciences; of the American Philosophical Society; American Bureau of Mines; the Société des Sciences et des Arts de Hainaut, Royal Society of Göttingen, Polytechnic Society of Kentucky, etc.

Chevalier de la Legion d'Honneur; Member of the Order of Nichan Iftabar of Turkey; Member of the Order of Medjidiah of Turkey; Chevalier of the Imperial Order of St. Stanislas of Russia.

List of scientific papers published by Dr. J. Lawrence Smith, arranged in chronological order, with references to the place of publication:*

1. Chromate of Potassa—a reagent for distinguishing between the salts of Baryta and Strontia. Sill. Journ., xxxvi, 1839, pp. 183–184.

2. A new method of making permanent artificial magnets by galvanism. Sill. Journ., xxxvi, 1839, pp. 335–337.

3. On the means of detecting arsenic in the animal body, and of counteracting its effects. Sill. Journ., xl, 1841, pp. 278–293; xlii, 1842, pp. 75–81; Sturgeon's Ann. Electr., vii, 1841, pp. 65–77.

4. The composition and products of distillation of spermaceti, with some few remarks upon its oxidation by nitric acid. Sill. Journ., xliii, 1842, pp. 301–321; Annal. de Chimie, vi, 1842, pp. 40–62; Journ. de Pharm., ii, 1842, pp. 169–179; Liebig Annal., xlii, 1842, pp. 241–254; Majocchi Ann. Fis. Chim., x, 1843, pp. 18–32; Sturgeon's Ann. Electr., x, 1843, pp. 28–44.

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* The Royal Society's catalogue to 1873 enumerates seventy-eight papers by Dr. Smith. The present list has been compiled by a careful comparison of the various journals and transactions cited, and nearly all the cross-references have been verified by the originals.

5. A short notice of the action of potash upon chloesterine. Sill. Journ., xliv, 1843, pp. 60–63.

*6. A review of the researches upon the dilatation of gases by M. V. Regnault. Amer. Journ. Sci, xliv, 1843, pp. 63–69.

7. A new instrument for estimating the quantity of carbonate of lime present in calcareous substances. Sill. Journ., xlv, 1843, pp. 262–266.

8. On the method of Drs. Varrentrapp and Will for estimating nitrogen in organic compounds. Sill. Journ., xlv, 1843, pp. 267–269; Sturgeon's Ann. Electr., xi, 1843, pp. 22–28.

9. Action of some of the alkaline salts upon the sulphate of lead. Sill. Journ., lxvii, 1844, pp. 81–84.

10. Actions of solutions of the neutral phosphates of the alkalies upon the carbonates of lime and some other insoluble carbonates. Source of fluorine in fossil bones. Composition of the marl from Ashley River, South Carolina, with an extract from a letter written by Prof. Bailey, of West Point. Existence of the oxide of cobalt in South Carolina. Sill. Journ., lxviii, 1845, pp. 97–104; Bibl. Univ., lvii, 1845, pp. 378–380.

11. A few remarks on the hygienic properties of ice, with an account of a new method of freezing water in a vacuum. Charleston, South. Journ. Med., i, 1846, pp. 149–156.

12. Observations on the more recent researches concerning the operations of the blast furnace in the manufacture of iron. Sill. Journ., i, 1846, pp. 170–178.

13. Freezing of water by the air-pump without the aid of sulphuric acid or any other desiccating agent. Sill. Journ., i, 1846, pp. 265–266.

14. Observations on the more recent researches in the manufacture of iron. Sill. Journ., ii, 1846, pp. 95–102.

*15. Oxide of cobalt and magnesian opal. 1846. "Sci. Researches" by J. Lawrence Smith, 1873.

16. On the annular eclipse of the sun, October, 1847. Sill. Journ., v, 1848, pp. 283–285.

17. Two new minerals—medjidite (sulphate of uranium and lime), liebigite (carbonate of uranium and lime). Sill. Journ., v, 1848, pp. 336–338; Liebig Annal., lxvi, 1848, pp. 253–256.

18. Emery formation of Asia Minor. Sill. Journ., vii, 1849, pp. 283–285.

19. Chrome and meerschaum of Asia Minor. Sill. Journ., vii, 1849, pp. 285–286; Ann. Sci. Disc., 1850, pp. 265–266; 1852, p. 293.

20. A list of the minerals associated with the emery of Asia Minor. Sill. Journ., ix, 1850, p. 289.

21. Memoir on emery: Part I—On the geology and mineralogy of emery, from observations made in Asia Minor. Sill. Journ., x, 1850, pp. 354–369;

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*Numerous intercalations have necessitated a departure from the numbering in the Royal Society's catalogue. The intercalated papers, which are from American sources, are starred.

Annal. des Mines, xviii, 1850, pp. 259–307; Comptes Rendus, xxxi, 1850, pp. 48–50.

22. Notice of a magnesian opal from near Harmanjick, Asia Minor. Amer. Assoc. Proc., vi, 1851, p. 242.

23. On the geology and general character of the meerschaum in the plains of Eski-Shehi (Asia Minor). Amer. Assoc. Proc., vi, 1851, p. 270.

24. On the geology of emery and corundum. Amer. Assoc. Proc., vi, 1851, p. 274.

25. Causes and prevention of the explosion of steam boilers. Journ. Franklin Inst., xxi, 1851, pp. 407–414.

26 Memoir on emery: Part II—On the minerals associated with emery: corundum, hydrargillite, diaspore, zinc-spinel, pholerite, ephesite (a new species), emerylite (a new species), muscovite, chloritoid (a new variety), black tourmaline, chlorite, magnetic oxide of iron, oligiste iron, hydrated oxide of iron, iron pyrites, rutile, ilmenite, and titaniferous iron. [1850.] Sill. Journ., xi, 1851, pp. 53–66. Compt. Rend., xxxi, 1850, pp. 191–193.

27. Liebigite. Sill. Journ., xi, 1851, p. 259.

28. On some of the thermal waters of Asia Minor. Sill. Journ., xii, 1851, pp. 10–16, 366–377; Amer. Assoc. Proc., vi, 1851, pp. 260–261; Erdm. Journ. Prakt. Chem., lv, 1852, pp. 110–114.

29. The inverted microscope. A new form of microscope, with a description of a new eye-piece micrometer, and a new form of goniometer for measuring the angles of crystals under the microscope. Sill. Journ., xiv, 1852, pp. 233–241 Ann. Sci. Disc., 1852, p. 148; Amer. Assoc. Proc., vi, 1851, pp. 76–77.

30. Warwickite. A borotantalite. Amer. Assoc. Proc., 1853, vii, pp. 147, 148.

31. Danburite. A silico-borate of lime. Amer. Assoc. Proc., 1853, vii, pp. 148, 149.

32. A new method of getting rid of sal-ammoniac in analysis. Sill. Journ., xv, 1853, p. 94; Ann. Sci. Disc., 1853, pp. 261–262.

33. New and ready method of determining the alkalies in minerals: Part I—The quantitative determination of the alkalies in the siliceous minerals not soluble in acids, with a note on a new method of forming the protoxyd of nitrogen. Sill. Journ., xv, 1853, pp. 234–243; Erdm. Journ. Prakt. Chem., lix, 1853, pp. 159-160; Ann. Sci. Disc., 1854, pp. 271–274.

34. New and ready method of determining alkalies in minerals: Part II—Conversion of the sulphates into chlorids; qualitative determination of the mixed alkalies; separation of the alkaline chlorids from each other, with a more direct method of obtaining them from silicates not soluble in acids. Sill. Journ., xvi., 1853, pp. 53–61; Erdm. Journ. Prakt. Chem., lx, 1853, pp. 244–247.

35. On the supposed new element, thalia. Sill. Journ., xvi, 1853, p. 95.

36. On a native borotitanate. Sill. Journ., xvi, 1853, pp. 293-294.

37. Note 1—Action of nitric acid on the chlorids of potassium and sodium. 2—Action of oxalic acid on the nitrates and chlorids of the same, with a ready

method of converting them into the carbonates. 3—The presence of oxalic acid enabling zinc to decompose water. Sill. Journ., xvi, 1853, pp. 373–375.

38. Re-examination of American minerals: Part IV—Boltonite, iodide of silver, copiapita, owenite, xenotime, lanthanite, manganese alum, apophyllite, schreibersite, protosulphuret of iron, cuban. Sill. Journ., xviii, 1854, pp. 372–381; Erdm. Journ. Prakt. Chem., lxiii, 1854, pp. 455–462.

39. Re-examination of American minerals: Part V—The minerals of the Wheatley mine in Pennsylvania: Anglesite, cerusite, wulfenite, vanadate of lead, pyromorphite, mimetene, galena, copper, copper pyrites, malachite, azurite, blende, calamine, hematite, fluor-spar, calc-spar, sulphur, etc. Amer. Assoc. Proc., ix, 1855, pp. 190–204; Sill. Journ., xx, 1855, pp. 242–253; Erdm. Journ. Prakt. Chem., lxvi, 1855, pp. 432–437.

*40. Minerals and mineral waters of Chili. U. S. Astron. Exped. (Gillis's Report of), ii, 1854, pp. 85–107.

41. Memoir on meteorites. Description of five new meteoric irons, with some theoretical considerations on the origin of meteorites, based on their physical and chemical characters. Sill. Journ., xix, 1855, pp. 153–163, 322–342; Erdm. Journ. Prakt. Chem., lxvi, 1855, pp. 421–428.

42. Report on Dupont's artesian well at Louisville, Ky. Sill. Journ., xxvii, 1859, pp. 174–178.

43. Account of several meteoric stones which fell in Harrison county, Indiana, 28 March, 1859. Sill. Journ., xxviii, 1859, pp. 409–411.

44. Description of three new meteoric irons from Nelson county, Ky., Marshall county, Ky., and Madison county, North Carolina. Sill. Journ., xxx, 1860, p. 240.

45. The Guernsey county (Ohio) meteorites. A complete account of the phenomena attending their fall, with a chemical analysis of them. Sill. Journ., xxxi, 1861, pp. 87–98.

46. Description of three new meteorites: Lincoln county meteoric stone, which fell in August, 1855; Oldham county (Ky.) meteoric iron; Robertson county (Tenn.) meteoric iron. Sill. Journ., xxxi, 1861, pp. 264–266.

47. Smith, J. Lawrence and G. J. Brush. Re-examination of American minerals: Part I—Emerylite, euphyllite, Litchfield mica, unionite, kerolite, bowenite, williamsite, lancasterite, hydro-magnesite, magnesite. Sill. Journ., xv, 1853, pp. 207–215. 2—Re-examination of American minerals: Parts II and III—Chesterlite, loxoclase, Danbury feldspar, Haddam albite, Greenwood mica, biotite, margarodite, chesterlite, talc, rhodophyllite, cummingtonite, hydrous anthophyllite, monrolite, ozarkite, dysyntribite, gibbsite, emerald nickel, danburite, carrollite, thalite, hudsonite, jenkinsite, lazulite, kyanite, elæolite, spodumene, petalite. Sill. Journ., xvi, 1853, pp. 41–53, 365–373; Erdm. Journ. Prakt. Chem., lix, 1853, pp. 161–167, 274–282; lxi, 1854, pp. 172–179.

48. Chladnite of the Bishopville meteoric stone proved to be a magnesian pyroxene. Amer. Journ. Sci.,† xxxviii, 1864, pp. 225–226.

† The change of name from "Silliman's Journal" to "The American Journal of Arts and Sciences," which took place at this time, is followed by the Royal Society's Catalogue.

49. Analysis of a new meteoric iron from Wayne county, Ohio, and some remarks on the recently-described meteorite from Atacama, Chili. Amer. Journ. Sci., xxxviii, 1864, pp. 385–387.

50. A new meteorite from Newton county, Arkansas, containing on its surface carbonate of lime. Amer. Jour. Sci., xl, 1865, pp. 213–216.

51. On the use of the bisulphate of soda as a substitute for the bisulphate of potash in the decomposition of minerals, especially the aluminous minerals. Amer. Journ. Sci., xl, 1865, pp. 248–249.

52. On the emery mine of Chester, Hampden county, Mass., with remarks on the nature of emery and its associate minerals. Amer. Journ. Sci., xlii, 1866, pp. 83–93.

53. A new meteoric iron, "the Colorado meteorite," from Russel Gulch, Gilpin county, near Central City, Colorado Territory. Amer. Journ. Sci., xlii, 1866, pp. 218–219.

54. On Colorado meteorites. Russel Gulch meteoric iron and Bear Creek meteoric iron. Amer. Journ. Sci., xliii, 1867, pp. 66–67.

55. On a new locality of tetrahedrite, tennanite, and nacrite, with some account of the Kellogg mines of Arkansas. Amer. Journ. Sci., xliii, 1867, pp. 67–69.

56. A new meteoric iron from Mexico. Amer. Journ. Sci., xlv., 1868, p. 77; Amer. Phil. Soc. Proc., x, 1869, pp. 330–331.

57. A new meteoric iron (the Wisconsin meteorite), with some remarks on the Widmannstättian figures. Amer. Journ. Sci., xlvii, 1869, pp. 271–272; Compt. Rend., lxviii, 1869, pp. 620–621.

58. The Cohahuila meteoric irons of 1868, Mexico. Amer. Journ. Sci., xlvii, 1869, pp. 383–385.

59. On the descloizite of the Wheatley mine, Pennsylvania. Amer. Journ. Sci., xlviii, 1869, pp. 137–138.

60. On the lesleyite of Chester county, Penn., and its relations to the ephesite of the emery formation near Ephesus, Asia Minor. Amer. Journ. Sci., xlviii, 1869, pp. 254–255.

61. Account of a fall of meteoric stones near Danville, Ala., with an analysis of the same. Amer. Journ. Sci., xlix, 1870, pp. 90–93; Cosmos, vii, 1870, pp. 232–234.

62. On the flight of a remarkable meteorite across the western portion of Ohio, near Forest, lat. 40° 50′ N. and long. 84° 40′ W. Amer. Journ. Sci., xlix, 1870, pp. 139–141.

63. Description and analysis of the Franklin county meteoric iron. Amer. Journ. Sci., xlix, 1870, pp. 331–336.

64. Remarks on the alkalies contained in the mineral leucite. Amer. Journ. Sci., xlix, 1870, pp. 335–336.

65. Description and analysis of a meteoric stone that fell in Stewart county, Ga. (Stewart county meteorite), on the 6th of October, 1869. Amer. Journ. Sci., l, 1870, pp. 339–341.

66. Some practical remarks on the use of flame-heat in the chemical laboratory, especially that upon burning gas without the aid of a blast. Amer. Journ. Sci., l, 1870, pp. 341–344.

67. On the precipitation of cæsium and rubidium salts with the insoluble salts of lime. Chemical News, xxii, 1870, pp. 150–151.

68. Phosphates of soda and potash. Amer. Assoc. Proc., xx, 1871, pp. 193–195. Amer. Chemist, ii, 1871, p. 207.

69. A regulator to maintain a constant level in the water-baths of a laboratory. Amer. Assoc. Proc., xx, 1871, pp. 195–197; Annal. Chem. Pharm., clxiii, 1872, pp. 191–192; Amer. Chemist, ii, 1876, p. 207.

70. The precise geographical position of the large masses of meteoric iron in North Mexico, with the description of a new mass—the San Gregorio meteorite. Amer. Assoc. Proc., xx, 1871, pp. 266–270; Amer. Journ. Sci., ii, 1871, pp. 335–338.

*71. A convenient form of specific gravity flask. Amer. Assoc. Proc., xx, 1871, p. 197; Amer. Chemist, ii, 1871, p. 200

*72. On bending glass tubes for fitting apparatus. Amer. Assoc. Proc., xx, 1871, p. 198; Amer. Chemist, ii, 1872, p. 244.

*73. A simple, clean, and convenient stand for filtrations. Amer. Assoc. Proc., xx, 1871, p. 198; Amer. Chemist, ii, 1872, p. 244.

74. Potash and its compounds. Amer. Chem., i, 1871, pp. 291–296.

75. Soda and salts of soda. Amer. Chem., i, 1871, pp. 339–345.

*76. The manufacture of sulphuric acid. Amer. Chemist, i, 1871, pp. 367–374.

77. On the determination of the alkalies in silicates by ignition with carbonate of lime and sal-ammoniac. Amer. Journ. Sci., i, 1871, pp. 269–275; Amer. Chem., i, 1871, pp. 404–407; Annal. Chem. Pharm., clix, 1871, pp. 82–92.

*78. Stearic acid industry. Amer. Chemist, i, 1871, pp. 414–420.

*79. Chlorine, fluorine, manganese, and carbonic acid. Amer. Chemist, i, 1871, pp. 442–448.

*80. Industrial production of oxygen, hydrogen, and other elements. Amer. Chemist, i, 1871, pp. 41–44.

81. Mineralogical and chemical composition of the stone that fell near Searsmont, Maine, 21 May, 1871. Amer. Journ. Sci., ii, 1871, pp. 200–201.

*82. Manufacture of illuminating gas from coal. Amer. Chemist, ii, 1871, pp. 11–17.

83. Ammonia, baryta, magnesia, and alumina. [1871.] Amer. Chem., ii, 1872, pp. 94–97.

*84. A new method for forming platinum black. Amer. Chemist, ii, 1872, p. 291.

85. Address delivered at the Portland meeting of the American Association, 1873. Amer. Assoc. Proc., xxii, 1873, pp. 1–26; American Naturalist, vii, 1873, pp. 577–602.

86. On getting rid of the accumulation of sal-ammoniac in mineral analysis. [1872.] Amer. Chem., iii, 1873, p. 201.

87. Conversion of the sulphates of the alkalies into the carbonates, tartrates, etc., in the moist way. Amer. Chem., iii, 1873, p. 241; Chem. News, xxvii, 1873, p. 316.

88. A description of the Victoria meteoric iron seen to fall in South Africa in 1862, with some notes on chladnite or enstatite. Amer. Journ. Sci., v, 1873, pp. 107–110; Compt. Rend., lxxvi, 1873, pp. 294–297.

89. Notes on the corundum of North Carolina, Georgia, and Montana, with a description of the gem variety of the corundum from these localities. Amer. Journ. Sci., vi, 1873, pp. 180–186; Compt. Rend., lxxvii, 1873, pp. 356–359, 439–442.

90. Masse de fer météorique découverte en creusant un fossé. Observations sur la structure moléculaire du fer météorique. Protochlorure solide de fer dans les météorites. Compt. Rend., lxxvii, 1873, pp. 1193–1197; Chem. News, xxix, 1874, p. 11.

91. On a mass of meteoric iron of Howard county, Ind., with some remarks on the molecular structure of meteoric iron and a notice concerning the presence of solid protochloride of iron in meteorites. Amer. Journ. Sci., vii, 1874, pp. 391–395; Annual Rec. Sci. and Indus.,† 1874, pp. 219-220.

92. Absolute alcohol. Amer. Assoc. Proc., xxiii, A, 1874, pp. 111–113; Annual Rec. Sci. and Indus., 1875, p. 538; Chem. News, xxx, 1874, p. 235; Amer. Chemist, v, 1874, p. 120.

93. Pure carbonate of soda. Amer. Assoc. Proc., xxxii, A, 1874, pp. 109–110; Chem. News, xxx, 1874, p. 234; Amer. Chemist, v, 1874, p. 119.

94. Pure carbonate of potash. Amer. Assoc. Proc., xxiii, A, 1874, pp. 110, 111; Chem. News, xxx, 1874, p. 235; Amer. Chemist, v, 1874, pp. 119–120.

95. Warwickite. Amer. Journ. Sci., viii, 1874, pp. 432–434; Annal. de Chim., iii, 1874, pp. 425–427; Compt. Rend., lxxix, 1874, pp. 696–697; Chem. News, xxx, 1874, pp. 217–218.

*96. The century's progress in industrial chemistry. Address delivered at "The Centennial of Chemistry." Amer. Chemist, v, 1874, pp. 61–70.

97. Curious association of garnet, idocrase, and datolite. Amer. Journ. Sci., iii, 1874, pp. 434–436; Compt. Rend., lxxix, 1874, pp. 813–814; Annal. de Chim., iii, 1874, pp. 428–430; Chem. News, xxx, 1874, pp. 241–242.

98. Laboratory notes: The limit of weighing; condensation of air on the surface of platinum; gold-lined capsules and crucibles; weighing on filters; a ready method of showing the absorption of hydrogen by palladium. Amer. Chemist, v, 1874, pp. 212–213; Chem. News, xxxi, 1875, pp. 55–56.

99. Analysis of ægirite from Hot Springs, Arkansas. Amer. Journ. Sci., x, 1875, p. 60.

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† Previously referred to as "The Annual of Scientific Discovery."

100. Description of the Nash county meteorite, which fell in May, 1874. Amer. Journ. Sci., x, 1875, pp. 147-148; Compt. Rend., lxxx, 1875, pp. 1453-1454.

101. Rapport sur la chute de deux pierres météoriques dans les États Unis. Compt. Rend., lxxx, 1875, pp. 1451-1454. (Included above.)

102. Anomalie magnétique du sesquioxyde de fer, préparé á l'aide de fer météorique. Compt. Rend., lxxx, 1875, pp. 301-304; Amer. Chemist, v, 1875, pp. 356-358; Chem. News, xxxi, 1875, pp. 210-212.

103. On the passage of two bolides, in 1872 and 1874, over Middle Kentucky. Amer. Journ. Sci., x, 1875, pp. 203-205.

104. A note in relation to the mass of meteoric iron that fell in Dickson county, Tenn., in 1835. Amer. Journ. Sci., x, 1875, pp. 349-352; Compt. Rend., lxxxi, 1875, pp. 84-87; Ann. Rec. Sci. and Indus., 1876, p. 225.

105. On troilite. Amer. Journ. Sci., xi, 1876, p. 68; Compt. Rend., lxxxi, 1875, pp. 976-978.

106. Sulfhydrocarbure cristallisé, venant de l'interieur d'un masse de fer météorique. Compt. Rend., lxxxi, 1875, pp. 1055-1056.

107. Researches on the solid carbon compounds in meteorites. Amer. Journ. Sci., xi, 1876, pp. 388-395, 433-442; Annal. de Chimie, ix, 1876, pp. 259-288; Compt. Rend., lxxxii, 1876, pp. 1042-1043.

108. On a bolide of January 31st that passed over Kentucky. Amer. Journ. Sci., xi, 1876, p. 458.

109. Sur l'arragonite observée á la surface d'un météorite. Compt. Rend., lxxxii, 1876, pp. 1505-1507.

110. Sur les combinaisons de carbone trouvées dans les météorites. Compt. Rend., lxxxii, 1876, p. 1507.

111. A new form of compensating pendulum. Amer. Journ. Sci., xii, 1876, pp. 106-107; Compt. Rend., lxxxiii, 1876, p. 202; Ann. Rec. Sci. and Indus., 1876, pp. xlvi-xlvii, Lond. Ed., and Dub. Phil. Mag. ii, 1876, pp. 237-238.

112. Aragonite on the surface of a meteoric iron, and a new mineral (daubréelite) in the concretions of the interior of the same. Amer. Journ. Sci., xii, 1876, pp. 107-110; Compt. Rend., lxxxiii, 1876, pp. 74-75.

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114. Puits de gaz en Pensylvanie. Annal. de Chimie, viii, 1876, pp. 566-571.

115. Examination of the Waconda meteoric stone, Bates county meteoric iron, and Rockingham county meteoric iron. Amer. Journ. Sci., xiii, 1877, pp. 211-214.

116. Note on the new localities of the columbic acid minerals, and two new columbates. Amer. Journ. Sci., xiii, 1877, p. 234.

117. Note of the recent fall of three meteoric stones in Indiana, Missouri, and Kentucky. Amer. Journ. Sci., xiii, 1877, p. 243; Compt. Rend., lxxxiv, 1877, pp. 398, 399.

118. Examination of American minerals: No. 6—Description of columbic acid minerals from new localities in the United States, embracing a reclamation for the restoration of the name Columbium to the element now called Niobium. Description and analysis of columbite, samarskite, euxenite, and fergusonite, and the new species hatchettolite and rogersite. Amer. Journ. Sci., xiii, 1877, pp. 359–369; Annal. de Chim., xii, 1877, pp. 253–264.

119. Sur deux nouveaux niobates. Compt. Rend., lxxxiv, 1877, pp. 1036–1038.

120. A description of the Rochester, Warrenton, and Cynthiana meteoric stones which fell, respectively, December 21st, 1876, January 3d, 1877, and January 23d, 1877, with some remarks on the previous falls of meteorites in the same regions. Amer. Journ. Sci., xiv, 1877, pp. 219–229; Compt. Rend., lxxxv, 1877, pp. 678–683; Annal. de Chim., xiii, 1878, pp. 41–59.

121. Tantalite. Amer. Journ. Sci., xiv, 1877, p. 323.

122. The earths of the cerium group as found in the North Carolina samarskite. Amer. Journ. Sci., xiv, 1877, p. 509.

123. Tantalite from Coosa county, Alabama, its mode of occurrence and composition. Amer. Journ. Sci., xv, 1878, pp. 203–204.

124. On the composition of the new meteoric mineral daubréelite, and its frequent, if not universal, occurrence in meteoric irons. Amer. Journ. Sci., xvi, 1878, pp. 270–272; Compt. Rend., lxxxvii, 1878, pp. 338–340; Amer. Assoc. Proc., 1878, xxvii, pp. 147–150.

125. Le Mosandrum; un nouvel élément Compt. Rend., lxxxvii, 1878, pp. 148–151; [Note on same—Amer. Journ. Sci., xvi, 1878, p. 384;] Lond. Ed. and Dub. Phil. Mag., vi, 1878, pp. 238–240; Arch. des Sci., Phys. et Nat., lxiii, 1878, pp. 165–172.

126. A short account of the nature of the oxide of the new element, Mosandrum. Amer. Assoc. Proc., xxvii, 1878, pp. 143–147.

127. Lettre à M. Dumas sur les matières organiques et l'air produisant un mélange explosible. Explosion d'un moulin à farine. Annal. de Chim., xiv, 1878, p. 144.

128. Note sur une nouvelle terre du group du cerium et remarques sur une méthode d'analyse des columbates naturels. Compt. Rend., lxxxvii, 1878, pp. 146–148.

129. Sur le fer natif du Groënland et le basalte qui le renferme. Compt. Rend., lxxxvii, 1878, pp. 674–676; Ann. Rec. Sci. and Indus., 1878, p. 286.

130. Note au sujet l'élément appelé mosandrum. Compt. Rend., lxxxvii, 1878, pp. 831–834.

131. Note sur un remarquable spécimen de siliciure de fer. Compt. Rend., lxxxvii, 1878, pp. 926–929.

132. Memoire sur le fer natif du Groënland et sur la dolerite qui le renferme. Annal. de Chim., xvi, 1879, pp. 452–505; [Note on same—Amer. Journ. Sci., xviii, 1879, pp. 72–73.

133. Sur des cristaux extraits de la fonte de fer par l'téher ou le pétrole. Compt. Rend., lxxxviii, 1879, pp. 888–890.

134. Figures de Widmannstätten sur le fer artificiel. Compt. Rend., lxxxviii, 1879, pp. 1124–1125.

135. Sur le spectre du nitrate de didyme. Compt. Rend., lxxxviii, 1879, p. 1167.

136. Daubrée's experimental geology [review of]: Part II—Experimental study of meteorites, with reference to certain cosmical phenomena. Amer. Journ. Sci., xix, 1880, pp. 386–390.

137. Study of the Emmet county meteorite that fell near Estherville, Emmet county, Iowa, May 10, 1879. Amer. Journ. Sci., xix, 1880, pp. 459–463, 495.

138. A new meteoric mineral (Peckhamite), and some additional facts in connection with the fall of meteorites in Iowa, May 10th, 1879. Amer. Journ. Sci., xx, 1880, pp. 136–137.

139. Hiddenite. An emerald-green variety of spodumene. Amer. Journ. Sci., xxi, 1881, pp. 128–130.

140. Occurrence of a nodule of chromite in the interior of a compact meteoric iron from Cohahuila. Amer. Journ. Sci., xxi, 1881, pp. 461–462; Compt. Rend., xcii, 1881, pp. 991–992.

141. Anomalie magnétique du fer météorique de Sainte Catherine. Compt. Rend., xcii, 1881, pp. 843–844.

142. Note on the magnetic properties of nickeliferous iron. Amer. Journ. Sci., xxiii, 1882, p. 232.

143. On the determination of phosphorous in iron. Amer. Journ. Sci., xxiii, 1882, pp. 316–320.

144. On the peculiar concretions in meteoric irons. Amer. Journ. Sci., xxv, 1883, pp. 417–423.

145. Methods of analyzing samarskite and the other columbates containing earthy oxides by the agency of fluorhydric acid; and of dissolving columbite and tantalite by the same acid. On the separation of thoria from the other oxides. Quantitative estimation of dilymium-oxide in its mixtures with other earthy oxides. Privately printed, Louisville, Ky., 1881, pp. 17, 8vo.

MEMOIR

OF

STEPHEN ALEXANDER.

1806-1883.

BY

C. A. YOUNG.

Read before the National Academy, April 17, 1884.

BIOGRAPHICAL MEMOIR OF STEPHEN ALEXANDER.

Mr. President and Gentlemen of the Academy:

Professor Stephen Alexander, one of the original fifty corporate members of the Academy, died at Princeton, New Jersey, on June 25th, 1883, after a lingering illness. He was nearly seventy-seven years of age, having been born September 1, 1806, in Schenectady, New York. His father, Alexander Alexander, was of Scotch extraction, an active and successful business man in Schenectady. He died in 1809, at the early age of forty-four, leaving his widow, with two small children—Stephen, the subject of the present sketch, and a younger sister, Harriet, who afterwards married her cousin, Joseph Henry. The elder Alexander, at the time of his death, possessed property considerable in amount; but it was to some extent in an unavailable form, much of it consisting of wild lands scattered about in the States of New York and Virginia. In the settlement of the estate a good deal of this landed property seems to have been frittered away and lost, but the homestead remained (a fine old stone mansion, built of materials brought from Holland, and still standing in Schenectady) and with it a sufficient amount of other property to put the widow far above want and to enable her to bring up her children in comfort and refinement.

The writer has no account of the childhood and youth of young Alexander. From his subsequent physique and character it is natural to infer that he was a delicate, quiet, sensitive, and studious boy—a mother's boy—rather than a sturdy, boisterous youngster. He must have had good schooling and must have been bright and somewhat precocious, for he completed his academic course before he was eighteen years old, graduating in 1824 at Union College with high honor.

He engaged in teaching immediately after graduation, and for several years was connected with an academy at Chittenango, New York. I have not been able to learn whether he then intended to make teaching his ultimate profession, or whether, like so many others, he only took it up for the purpose of procuring funds to enable him to go on with professional studies in some other direction;

nor do I know whether, before going to Princeton, he had any other engagement than that at Chittenango. I am disposed to think, however, that in 1830 and 1831 he may have been connected with the Albany Academy. At any rate in 1829 his mother moved to Albany, with her family, and letters and papers in the possession of the family show that in 1830 and 1831 he was making numerous astronomical observations in Albany and communicating them to the Albany Institute. It is not unlikely that the fact that Professor Henry had been appointed to a chair in the Albany Academy in 1828, and was then entering upon his distinguished career, may have determined the removal of the Alexander family to Albany. Professor Henry was the son of the elder Alexander's sister, and in 1830 he married his cousin, Miss Alexander, thus establishing a double relationship, which unquestionably shaped the whole life and fortune of hs younger and favorite cousin and brother-in-law.

In 1832 Professor Henry accepted a call to the chair of natural philosophy in the College of New Jersey, and removed to Princeton with his family. Young Alexander came with them and entered the Theological Seminary as a student, intending to fit himself for the Presbyterian ministry.

In 1833, however, he was appointed to a tutorship in the college, and began his fifty-three years' service as a member of its faculty.

In 1834 he was made adjunct professor of mathematics, and in 1840 he was promoted to the full professorship of astronomy, which he retained until 1876. During the long intervening period the style and duties of his professorship were several times more or less modified. For several years after the death of Professor Dod he was professor of mathematics and astronomy. When Professor Henry went to Washington he gave up the mathematics and became professor of natural philosophy and astronomy; but he always held fast to the astronomy.

In 1876 he was retired from active service at the age of seventy, and made professor emeritus, with a suitable provision from the funds of the college for his declining years.

The last six years of his life he spent in dignified retirement and quiet, always busy with head and pen, but, on account of his continually growing feebleness, not appearing much in public nor able to complete many things for the press. Some months before his death he met with a singular accident (a fall out of bed) by which he fractured an arm and dislocated the shoulder. The dislocation

was easily reduced, and, rather contrary to expectation, the broken bone reunited kindly. He never recovered his strength, however, but gradually faded away until at last he died apparently from mere exhaustion.

In 1836 he married Miss Meads, of Albany, who died in 1846, leaving three daughters, two of whom are still living, both married. Four years later, in 1850, he married Miss Forman, of Princeton, who survives him, with two unmarried daughters.

In 1839 he was elected a member of the American Philosophical Society of Philadelphia, and in 1850 he became a fellow of the American Academy of Arts and Sciences in Boston.

In 1852 Columbia College conferred upon him the degree of LL. D.

He was early and for many years a prominent member of the American Association for the Advancement of Science, and served as its president at the Springfield meeting of 1859.

In 1862 he was one of the fifty original members named in the bill which brought into existence our National Academy of Sciences.

As has already been incidentally mentioned he began astronomical work in 1830. In that year he observed a considerable number of star occultations at Albany and worked out the longitude of the place. In 1831 he went to Maryland to observe the annular eclipse of February 12th, and ever after was enthusiastic and indefatigable in the pursuit of such phenomena, never losing an opportunity.

In 1834 he went to Georgia to observe the total eclipse of that year, exulting in the possession of a fine 3½-inch telescope by Fraunhofer, which had just been presented to the college by some of its liberal friends. This instrument was his pride and delight to the very end of his life. Not long before his death he had been looking at Saturn with it early one evening and afterwards came over to the Halsted Observatory to take a look at the same object with the great 23-inch telescope then newly mounted. We had a magnificent view, but, as I accompanied him to the door, he stopped and said in his peculiar way: "Yes; you have more light, but the little Fraunhofer holds its own *amazingly* well."

At the time when it was procured, however, if I am not mistaken, "the little Fraunhofer" had no superior in the country except the 5-inch Dollond telescope presented by Mr. Clark to Yale College four years earlier. I have never seen any published report of Pro-

fessor Alexander's observations of this eclipse of 1834, though I have found several allusions to them in Silliman's Journal and elsewhere.

In 1860 he was the astronomical chief of the large party sent out by the Government to observe the eclipse of that year in Labrador. The expedition was entirely successful, and its valuable results are published in the Coast Survey report for that year.

In 1869 he was the chairman of the committee apointed by this Academy to organize the observations of the eclipse of August 7th and himself took part in the observations at Ottumwa, Iowa. My own first experience in eclipse observation was at this time, and simple gratitude requires that I should put on record here how courteously and kindly he responded to my application for a place on one of the parties, and how considerately he assigned my work. In 1838, 1854, 1865, and 1875 he observed the annular eclipses of those years, though in 1875 clouds prevented anything more than a glimpse. In 1878 he was anxious to go with the Princeton party to Denver to observe the total eclipse of July 29th, but his health was then too feeble to permit such a journey. He observed it, however, at Princeton as a partial eclipse, as he had a number of others in preceding years.

In 1835, in connection with Professors Bache, Espy, and Henry, he determined the difference of longitude between Princeton and Philadelphia by observations of meteors. Although the method had been suggested more than a century before by Halley, and the suggestion had been several times renewed by others, yet, so far as I can learn, this was the first occasion on which it was actually put in practice, and the only time in the United States. A few years later it was made use of in a few instances in Germany, Ireland, and Italy. But the telegraph soon superseded all other methods for longitude purposes.

He aided Professor Henry in his thermopile observations upon sun-spots in 1845 and in many other physical researches. He observed four transits of Mercury, and in December, 1882, he closed the record of more than fifty years by a careful and satisfactory observation of the transit of Venus. I think he never put his eye to the telescope again.

But Professor Alexander's special forte was not that of the observer. He was not satisfactorily equipped with instruments or observatory. The whole astronomical outfit of Princeton College

during his professorship was hardly equivalent to that of the ordinary High School of to-day. Nor had he the time for any connected and persistent observation, nor, probably, the mechanical taste and skill, nor the physical strength and endurance necessary to distinguished success in that kind of work. He was, however, extremely anxious to get the means for careful study of the nebulæ, for which purpose, of course, a large telescope is simply indispensable. He spared no efforts, therefore, to obtain such a telescope with a corresponding observatory. The observatory came first, through the liberality of his friend and admirer, General Halsted, whose name it bears. Its corner-stone was laid in 1866, and it was completed in 1872. It was nearly ten years later before the great telescope was mounted by the generous aid of other friends of the college, not, indeed, until after his retirement from the professorship. But he saw it at last, and I had the pleasure of directing it for him upon some of those remarkable objects so long familiar to him in the drawings of Herschel, Rosse, and Lassell, but which he had never before examined for himself. There was something pathetic in his exclamations of satisfaction and delight, for the great instrument, so long dreamed of, had only come too late for him to use it. He had labored, and others had entered into his labors, and were to reap the fruit; but he was unselfish, and rejoiced sincerely in the good fortune of his successor, so greatly due to his own exertions.

As was the case with all college professors thirty years ago (and still is with many of us) his time and strength were so consumed by the routine duties of the office—in the class-room and faculty meeting—that little remained for anything else. Still he accomplished a good deal with his pen. While he wrote no books and could not be called a prolific author, he published a considerable number of articles in the various scientific periodicals. The published articles are, however, few in comparison with the number of papers which he presented orally before the different scientific bodies with which he was connected. He was a fluent speaker, and rather preferred to present his subject from skeleton notes than to read a written essay, and after presenting a paper, like some of the rest of us, he greatly disliked the mechanical labor of preparing it for the press, so that the only record we have of much of his work is a mere notice or a brief abstract of a paper read on such and such a date.

Probably the most important published essays from his pen are the four following: A paper upon the "Physical Phenomena Attend-

ant upon Solar Eclipses;" one on "The Fundamental Principles of Mathematics;" one on "The Origin of the Forms and the Present Condition of the Clusters of Stars and Several of the Nebulæ," and his treatise on "Certain Harmonies of the Solar System."

The first of these was read before the American Philosophical Society of Philadelphia, at its centennial anniversary in 1843, and is published (by abstract) in the volume of Proceedings then issued. It shows a very extensive range of reading, and is an exceedingly thorough, orderly, and exhaustive summary of everything that had ever been reported as observed on such occasions. There is, however, hardly sufficient discrimination between the real and imaginary—between observations which can be depended on and others which are obviously mere fancies of an untrained observer.

The paper on the "Fundamental Principles of Mathematics" was first read before the American Association for the Advancement of Science in 1848, and afterwards published in the American Journal of Science and Art. It is an interesting, suggestive, and eloquent essay. The subject gives the author an opportunity to indulge his inherited Scotch love for metaphysics and hair-splitting distinctions, and he finds in it also opportunity for imagination and poetry to an extent which makes the paper almost unique among mathematical disquisitions.

Professor Alexander's discussion of the forms, &c., of nebulæ and star clusters appeared in Gould's Astronomical Journal in a series of articles running through many numbers. Its main purpose was to show that many of the nebulæ and clusters are not stars in the process of formation, but of disintegration; that the nebular condition sometimes follows instead of preceding the stellar.

Laplace's Nebular Hypothesis had always a powerful fascination for him. He made it the basis of endless speculations as to the origin and genesis of the present state of things, and though he sometimes reached conclusions difficult to reconcile with it, as commonly understood, he was always persuaded of its essential verity. His most elaborate, extensive, and undoubtedly, in his own estimate, his most important, work was the treatise upon the "Harmonies of the Solar System," published in the Smithsonian Contributions to Knowledge in 1875. It contains the summing up of his chief work for many years. In it he considered that he had established the existence of certain distance-determining ratios in the spacing of the planets, and also in that of their satellite systems—such relations as

might be supposed to result from the previous existence of the planets and satellites in the condition of rings analogous to those of Saturn. The spirit and method of the work resembles that of Kepler rather than that of Newton, Laplace, or the modern geometers, and quite justifies the title of the "American Kepler," conferred upon the author by a foreign critic.

As a scholar Professor Alexander was unusually broad and versatile. He was an excellent linguist, familiar with Latin, Greek, and Hebrew, and with the principal European languages, all of which he read, and several of them, I believe, he wrote and spoke with facility. He was fond of general literature, of history, biography, fiction, eloquence, and poetry, and himself wrote verses of no mean merit. He was an ardent lover of metaphysics (especially of the Scotch school), of philosophy, and of theology. He was familiar not only with the ordinary range of mathematical reading but with many works of higher order. He had large portions of the Mechanique Celeste almost at his fingers' ends, and was well acquainted with the works of Newton, Euler, and Lagrange. To an extent unusual in his time he also kept up with the current astronomical literature by means of the foreign journals, which were then not easy to obtain in this country.

His principal work, of course, was in the college, and there is no question that he exercised a most important influence upon the hundreds, even thousands, of pupils who came under his instruction at Princeton during his protracted term of service. Upon many of them he impressed himself deeply, and was always remembered by them with reverence and affection. As a lecturer, especially, he had the power of exciting interest and enthusiasm.

I cannot do better than to quote in this connection from an address delivered at his funeral by the Rev. Horace G. Hinsdale, his pastor, a graduate of more than thirty years' standing, who remembers our friend in the fullness of his strength and power. After speaking of Professor Alexander's distinguished associates in the Princeton faculty, Dod, Torrey, J. W. and J. A. Alexander, Hope, Henry, and Guyot, Mr. Hinsdale proceeds as follows:

"Of such associations Stephen Alexander was not unworthy. He pushed his researches into the depths of mathematical and astronomical science, availing himself of his acquaintance with the principal languages of Europe. He printed for the use of his students treatises on ratio and proportion, differential calculus, and astronomy. He was unselfish in his devotion to the

interests of the college and the advancement of learning. He aroused the admiration of his pupils by the evident extent of his knowledge and his ardor in imparting it, although it must be said that he often became so profoundly interested in setting forth the philosophy of mathematics as to forget that their acquaintance with the subject was of necessity far less than his own, and so to outrun their ability to follow and comprehend him. The closing lectures of his course in astronomy, in which he discussed the nebular hypothesis of Laplace, were characterized by a lofty and poetic eloquence, and drew to his class-room many others than the students to whom they were addressed. Even ladies from the village and elsewhere—so far did the traditional conservatism of Princeton give way before a wholesome pressure—invaded Philosophical Hall (a historic building, whose demolition is mourned by many an alumnus), and taxed to the utmost the gallantry of the collegians. I vividly recall one of the occasions of which I speak—the hushed and expectant auditory; the shy, almost abashed, manner of the lecturer; the rapt look, the glowing countenance, the throbbing frame, which indicated how completely he was possessed by his theme; the magnificent sweep of his ideas concerning the formation of the material universe with its countless suns and systems; his happy application of Scripture phrase when, pointing to the drawings of certain nebulæ of remarkable form, he would quote: 'They all shall wax old as doth a garment, and as a vesture shalt thou change them, and they shall be changed;' the outburst of eloquence, seeming to our young minds akin to inspiration itself, with which he ascribed all the beauty and glory of creation to Him who is enthroned in majesty above all spheres, evermore controlling and guiding all, the Personal God, glorious in holiness, fearful in praises, doing wonders."

The last sentence of this passage which I have quoted brings to notice one of the most distinctive characteristics of our friend. He was through and through religious, in his belief, in his feelings, and in his life, and in everything he said and did his Christian faith shone out.

In person he was small and slight, and during the latter years of his life frail and feeble. He probably never weighed as much as one hundred and twenty pounds in his very best estate. His countenance was refined and delicate; his manners were always gentlemanly and courteous, but usually rather retiring and reserved until some interesting topic made him forget himself; then he was fluent and even impetuous in conversation. He was modest almost to shyness, though not without a reasonable and comfortable underlying consciousness of his real worth and ability, pure of thought and speech, simple-hearted and unsuspicious as a child, gentle and quiet usually, but capable of high enthusiasm or burning indignation when occasion came. He was a good and patriotic citizen, and

an earnest and active member and officer of the church to which he belonged—always prominent in its work and counsels.

It is difficult to assign just rank on the roll of scientific honor to those who have lived and labored under circumstances widely different from our own. Obviously earlier workers cannot be fairly judged by the standards of to-day, because their means and opportunities were not those of the present time.

While some, like Franklin, Bache, and Henry, stand pre-eminent when judged by any standard, whether of the present or the past, in respect either to ability or performance, the great majority of those upon whose influence and labor the progress of science has mainly depended, stand together as an honorable body, among whom it is not easy to establish well-marked grades and ranks; and fortunately it is not necessary.

It would be a mistake to claim for Professor Alexander a rank among the pre-eminent few. He made no great discoveries, nor has he left any record of scientific work of such importance or extent as to entitle him to such a position. But there can be no question that among the more numerous class referred to he should be accorded a most honorable place. His native ability was of a high order and his influence upon his pupils by his instructions, and upon the general community by his various discourses and by his published works and observations, has contributed powerfully and effectually to the progress of his favorite science. American astronomy to-day owes much to his life and labors.

To say that he was without weaknesses or faults would be untrue of course; but I am sure of this, that few men have ever lived more blameless and useful lives, and few will be remembered by those who knew them best with more affectionate reverence than he.

One of his early friends (the Rev. George Burrows, of San Francisco), in a letter received not long before his death, writes to him thus: "I never had a friend whom I valued or admired more highly for all that is precious in purity, honor, delicacy, piety, steadfastness, and nobleness of character. I can never see you again on earth, but one of the additional attractions of heaven is the assurance of meeting you there."

MEMOIR

OF

JOHN LAWRENCE LeCONTE.

1825-1883.

BY

SAMUEL H. SCUDDER.

Read before the National Academy, April 17, 1884.

BIOGRAPHICAL MEMOIR OF JOHN LAWRENCE LECONTE.

The revocation of the edict of Nantes, with its attendant persecutions and other horrors, was incidentally of advantage to science; for of the tens of thousands who expatriated themselves from a community given over to tyranny and fanaticism, not a few carried with them and transmitted to their offspring, born in the land of refuge, a spirit of scientific investigation, which was doubtless quickened by the intense life of the time; and in after years, when the hereditary trait again appeared, it may often have found its healthy growth re-enforced by the admixture of the new element afforded by residence in a foreign country. At all events other countries owe much of their scientific fame to the men of Huguenot ancestry, who fled from the intolerance of Louis XIV, and whose influence outside of France would but for this have certainly been lessened for lack of direct contact; for among the Huguenots, or their descendants, as has frequently been pointed out, was an unusual proportion of men devoted to science, literature, and the arts. Thus, to mention but a few names, Switzerland owes to this movement her DeCandolles, and Saussures, with Plantamour and a host of lesser lights; Germany and Holland, Charpentier and Lyonet; and our own country, Bowdoin, of Cambridge, an early president of the American Academy; John Jay, of New York, and the LeContes, living and dead.

The name of LeConte, or LeComte, as it was indifferently spelled, was a frequent one in France in the fifteenth and sixteenth centuries, and particularly in Normandy. The families were mostly of noble blood, and many were possessed of considerable estates; others, however, were born in poverty, of whom some came to a more honorable distinction than wealth or title could give, such as the learned Antoine LeConte, a jurist of Noyon, famous for his attacks on Calvin, or the other Antoine, possibly a direct descendant, who was Baron de l'Echelle and governor of Sedan, and was well known

in Huguenot times for his controversial letters addressed to a Jesuit; but whether of noble or plebeian blood we rarely find their names in those days, excepting as stanch Huguenots, and without leaving Normandy we come to such cases as that of Isaac LeComte, of Coutances, who, in 1687, at the age of sixty, was sentenced to the galleys because a book "of the religion" was found in his house; and of Daniel LeConte, of Poitou, sent to the galleys the following year for the crime of being a Huguenot; of Abraham and Henry LeConte, who fled to England in 1687 for conscience and life's sake; and of Guillaume and Pierre LeConte, besides others of the same name, who took refuge in our country.

Guillaume, with whom we are specially concerned, was born at Rouen, March 6, 1659. His exact ancestry is unknown; but from seals still in the possession of the family, and to judge from the researches of Dr. LeConte, it seems tolerably evident that he was descended, through his mother or grandmother, from the barons of Nonant, a Norman family of importance, and that he or his father adopted the name of the maternal line.* In the troubles which arose in his early manhood, Guillaume, finding that neither justice nor liberty would be allowed him in his native country, fled to Holland and cast in his fortunes with the Prince of Orange. "At the time of his arrival in Holland," writes Major LeConte in a manuscript at hand, "William, the Stadtholder, was preparing to invade England, and readily accepted the offer of my ancestor's service in his army. With him he proceeded to England," and apparently remained in his army until it was disbanded after the peace of Ryswick, for we find him with that army at the conquest of Ireland, and the family still retain a fine folio Elzevir Bible of 1669, presented to Guillaume by William III, in token of his friendship. Moreover it was in the year following the peace of Ryswick, namely in 1698, that Guillaume emigrated to this country with two nephews,

*Dr. LeConte, in a letter to Rev. C. W. Baird, says: "The tradition in my family is that my ancestor was so disgusted with the political conditions of France that when he went to Holland he dropped his father's and took his mother's name. . . . The LeConte seal is quartered at the lower right hand corner, and indicates a female of the family of that name of the seigneurs of Nonant, Bretoncelles, etc." But it is not known, I believe, that any Huguenots changed their name for the cause here assigned, and it seems more probable that the change was made by himself or an ancestor for some purely family reason.

Thomas and Henri, of the Nonant line. These two nephews, it may be said in passing, married in this country, but left no children.

Shortly after his arrival in New York he is said to have made a voyage to the West Indies,* where he met and married, February 16, 1701, Margueritte de Valleau, daughter of Pierre Joyeulx de Valleau, of Martinique. If so, he soon returned to New York and purchased a considerable estate, aided by presents from King William. His wife's father must soon have died, perhaps before they returned to New York, for they early came into possession of her father's estates in Martinique, and sold in New York the sugar produced thereon. The date of his wife's death is not known, but it could not have been long after the birth of their only son, William, (December 3, 1702), for on April 17th of the following year he married a second time, Margaret Mahant (Mahoo, Mahoe, or Mahault), by whom he had two other children, Pierre and Esther. He and his second wife died in New York on the same day, September 15, 1720, of yellow fever.

William, the son of the first wife, married Anne (Marie Ann) Beslie, of New Rochelle,† and had two daughters, through the second of whom, Susanne, who married another Besley (or Bayley), comes the family of that name, in whose succession were Mother Seton, the founder of the Sisters of Charity in this country, and the late Archbishop Bayley, of Baltimore.

Of the marriage or descendants of Esther nothing is known to

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* "No evidence has been recorded to show that Guillaume ever went to Martinique; it is much more probable that Margueritte had come with her father to New Rochelle, but continued to refer her home to the island from which they had emigrated."—Family records by Prof. LeConte Stevens. It may be added that the name of Pierre Valleau appears on the New Rochelle list from the earliest period.

† A romantic story is told of this son in Major LeConte's manuscript to the effect that he made a visit to his mother's relatives in the West Indies, and was there betrothed to a Miss Dugand. Before the time of the proposed marriage business took him to New York for a few months, and he then returned to claim his bride. On landing at St. Pierre's and inquiring about his betrothed, who lived some miles out of the city, he was told she had married, whereupon he at once re-embarked on a vessel just sailing for New York, determined to marry without delay the first lady who should show any regard for his attentions. In a few days he met Miss Beslie, and soon married her. He afterwards learned that it was another Miss Dugand, and not his betrothed, of whose marriage he had heard.

me.* The descent of the family name comes through Pierre,† who lived in New Jersey, and married, first, Margaret Pintard, and, three years later, Valeria Eatton, of Eattonville, New Jersey. The first left no children, the second five—William, John Eatton, Margaret, Thomas, and Peter. William married, but died childless. Thomas and Peter did not marry. Margaret married Rev. Jedediah Chapman, one of the founders of the Presbyterian church in this country. So again the male descent and name comes solely through one son, John Eatton, who was born September 2, 1739, and married Jane Sloan in 1776, by whom he had three children—William, who died at the age of thirty, unmarried; Lewis, born in 1782, who lived in Georgia, where he married Anne Quartermann, and was the father of Professors John and Joseph LeConte, of the University of California, the only living children out of four sons and three daughters; and finally John Eatton, born in Shrewsbury, New Jersey, February 22, 1784, who married Mary Anne H. Lawrence in July, 1821, and had three sons, two Edwards, both of whom died in infancy, and the subject of the present notice, John Lawrence, who was born May 13, 1825.‡

As the life of Dr. LeConte was an uneventful one, its principal incidents may be merely sketched. At the completion of his collegiate course at Mt. St. Mary's College, in Emmettsburg, Maryland, he entered the College of Physicians and Surgeons in New York, from which he was graduated in 1846. Although he thus made medicine his declared profession, he never followed its practice to any extent, inheriting, as he did, means sufficient to render him independent. From 1848 to 1850 he made several journeys to Lake Superior and California to increase his knowledge of our fauna. In 1852 his father's family removed to Philadelphia, where he has since resided, marrying in 1861—the year after his father's death—the daughter of the late Judge Grier, who, with two sons, survives him. He made other expeditions at various times, both before and after his marriage, to Honduras and Panama, the Rocky Mountains, Europe,

* See Appendix.

† "Dr. Peter LeConte . . . settled in New Jersey, becoming a resident of Monmouth county as early as 1734. In Middletown he practiced medicine for many years, and there is a tradition that he sometimes preached as a minister."—Family records by Prof LeConte Stevens.

‡ Fuller details of the genealogy of the family will be found in an appendix.

Egypt, and Algiers. At the outbreak of the civil war he entered the army medical corps as surgeon of volunteers, and was soon advanced to the post of medical inspector, with the rank of lieutenant colonel, where he remained until the close of the war. In this field his fine organizing power and good sense showed themselves to excellent advantage. After this he held no post demanding his time until 1878, when he entered the United States Mint in Philadelphia, a position which he retained until his death, which occurred November 15th last.

Francis Galton, in his work on "Hereditary Genius," and Alphonse DeCandolle, in his "Histoire des sciences et des savants depuis deux siecles," have clearly proved the influence of heredity in the development of scientific men. To meution a single example, DeCandolle points out that among the ninety-two persons who had been the chosen "foreign associates" of the French Academy of Sciences up to the time of his writing, a father and a son occur no less than four times, a number which is suprising when we consider that the election was made out of about twelve hundred men of science. The influences which affect the study of this question among ourselves are diversified, for here, perhaps, better than anywhere else in the world, one may carve out one's own destiny, and a man of genius may consequently more readily rise from the lower ranks; our lineage, too, is so much more mixed, aud in a large proportion of cases so obscure, that the traces of hereditary character are less readily discernible; yet, to pass by all names that are in close relation with European immigration, we have some clear instances of family influence in science alone, as may be seen by repeating merely the names of Dana, Draper, Eatton, Harris, Hitchcock, Pickering, Pierce, Rogers, and Whitney, and especially LeConte, while if we were to include, as we should, the mother's side, we should have to add such related names as Franklin and Bache, to which, no doubt, a serious research would add illustrious examples. But the historical element of our country is so modern, our professional life so unstable as it were, the growth and opportunities of scientific culture so recent, that in nearly all these instances we have but the connection of a single pair of names; hence it is that the name of LeConte is here somewhat conspicuous.

Pierre, the great-grandfather of Dr. LeConte and son of the original Guillaume, was a physician of some distinction in his day, and possessed, through his success, considerable property. His second wife,

through whom the descent comes, was a sister of Dr. Joseph Eatton. The sons all appear to have been men of more than ordinary character, but it is not known that any of them had any special scientific tastes. The eldest, William,* moved to Georgia, and the others followed, spending the winters on their plantations there, but still retaining their possessions in the North. John Eatton, the first, probably lived at first at Shrewsbury, as his children were all born there, summer and winter.† But he had interests with William in Georgia, and ultimately removed there to a plantation of his own in Liberty county, where, in the open life of the South, his sons (or at any rate all but William, who died unmarried, in early manhood) developed a strong taste for the study of nature, which one can hardly believe was not from some predilection or guidance on their father's part. However that may be, Louis, who lived, married, and died in Georgia, succeeding there to his father's estates, was a man of unusual attainments for those days in many departments of science, and although he never published any of the results of his studies he contributed freely to the labors of others. He studied medicine in his youth with Dr. Hosack. He established on his plantation in

* "William LeConte . . . was a lawyer by profession, and took an active part in the Revolutionary struggle. On the 22d of June, 1775, he was appointed a member of the first 'Council of Safety' for the Province of Georgia, and was likewise a member of the 'Provincial Congress' which met in Savannah on the 4th of July, 1775, representing the Parish of St. Philip, or great Ogeechee. On the 8th of August, 1775, as a member of the Council of Safety, he signed a letter addressed to Governor Sir James Wright, and his name appears on the 'black list' which the royal Governor of Georgia sent to England, with the annexed title of 'Rebel Counselor.'"—Family records by Prof. LeConte Stevens. See also Rev. Dr. Stevens' History of Georgia, Vol. II, pp. 101, 105, 123.

† "William and John Eatton must have removed to Georgia some time before the breaking out of the American Revolution, but in after life they seem to have divided their time between Georgia and New Jersey. They are said to have carried on jointly a profitable lumber business with the West India Islands, from their lands at 'Sans Souci,' on the Ogeechee river, about sixteen miles south of Savannah. . . . John Eatton, . . . after living with his brother at Sans Souci, in Georgia, purchased extended lands adjacent to the southern boundary of the 'Midway Settlement,' in Liberty county, about twenty miles south of Sans Souci. The exact date of this purchase is not now known. There is no evidence that he adopted any learned profession, or had any occupation beyond that of taking care of his property."—Family records by Prof. LeConte Stevens.

Georgia a botanical garden, which was especially rich in bulbous plants from the Cape of Good Hope, and a laboratory, in which he tested the discoveries of the chemists of his day. He devoted much time also to mathematical studies, and manuscripts on this subject, as well as on the animals and plants of Georgia, were in the possession of his family, but perished during the war in the burning of Columbia in February, 1865.* Of his four sons two died at about

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* "While in college (Columbia College) with his younger brother, John Eatton, Lewis manifested a marked fondness for natural science. He made a botanical exploration of Manhattan Island before his removal to Georgia, where the enlargement of the field of observation and research led to the cultivation of nearly all the branches of natural science, including botany, zoölogy, chemistry, and physics. Aided by his brother, John Eatton, he introduced improvements in the culture of rice lands, reclaiming much of 'Bulltown swamp,' which traversed his estates.

He made himself thoroughly familiar with the botany and zoölogy of the entire coast of Georgia, and upon one of his plantations in the neighborhood of the homestead he established a botanical garden, which was especially rich in bulbous plants. He was among the first to produce the beautiful hybrid known as Amaryllis Johnsonii. His camelias, which were cultivated in the open air, were famous, the trunk of one of these trees, a double white, attaining a diameter of thirteen inches or more near the ground and a height of nearly twenty feet. As late as 1860 this garden, though abandoned, was remarkable, and during that year I saw in it camelia trees over twelve feet in height. . . . In consequence of an unconquerable aversion to appearing in print he published nothing himself, but handed the fruits of his investigations over to his scientific friends. The monographs of his brother, Major LeConte, . . . were enriched by his observations. In like manner Stephen Elliott, of South Carolina, and other contemporary botanists acknowledged their obligations to him. He made excursions into the adjacent counties, including one of the regions bordering on the Altahama river, in company with the botanist, Dr. William Baldwin, U. S. A., and a subsequent excursion with Mr. Gordon, the Scotch collector and botanist, who published an account in the *Gardener's Magazine*, Vol. VIII, of the result of many months' residence with Mr. LeConte. . . . Mr. Gordon asserts that Lewis LeConte's garden is the richest in bulbs that he has seen. He gives Mr. LeConte the credit of having solved the problem of the 'natural succession of forest trees.' In one of the upper rooms of his house at Woodmanston Lewis LeConte established a chemical laboratory. . . . His varied and accurate knowledge of science, especially of medicine, was of great service to the community in which he lived. He also devoted considerable attention to mathematical subjects, and among others to that of 'magic squares.'"—Family records by Prof. LeConte Stevens.

the age of thirty, one of them (Lewis)* already showing a strong taste for science, while the others, still living and members of our own body, are sufficiently known to you to need from me no statement of their important and varied contributions to science. The same tastes were developed also among his daughters.†

The youngest son of John Eatton, bearing his father's name, and who was the father of Dr. LeConte, is better known than his brother in scientific literature. He lived most of his life in New York, inheriting that portion of his father's landed property which lay in

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* "Lewis LeConte . . . entered Franklin College, Athens, Ga., in 1838, and after graduation went to Cambridge, Mass., where he studied law. . . . In boyhood Lewis manifested much mechanical ingenuity; was very fond of the chase, and attained extraordinary skill in the use of the rifle. At college he was specially interested in chemistry, and this interest he retained afterward. . . . His love of science was for its own sake rather than for any material benefit to be derived from its application. . . . Had he lived longer there is reason to think his attention would have been concentrated upon science. He never exhibited any fondness for politics, but, like his father, kept a private chemical laboratory in his house, and rather avoided public life."—Family record by Prof. LeConte Stevens.

† "Ann LeConte . . . was specially characterized by her ardent love of nature, her keen appreciation of art, so far as opportunities for culture in this were presented, her high sense of duty, and her devotion to religion. Her love of nature was an inheritance, and showed itself especially in her fondness for flowers, which was early imbued by her father. Wherever her home was made a flower garden was to her an indispensable adjunct, and the zeal and industry applied in its cultivation were never unrewarded. . . . That her mind was naturally of mathematical order was shown by her precision in music and her clear conception of form, of proportion, of number. Her advancement in this department of study in girlhood was uncommonly rapid; without further development it was only possible for such tendencies to continue presenting themselves through life without resulting in the accomplishment of any special work that might command public recognition. When the homestead in Walthourville was contemplated she studied architecture and landscape gardening, and not a single feature in the plan of the house and its surroundings was decided without her scrutiny, criticism, and decision."

One of her children, Walter LeConte Stevens, from whose "family records" I have taken the above and previous notes, a professor in the Packer Collegiate Institute of Brooklyn, N. Y., and who graduated in 1868 from the University of South Carolina, has contributed also to the renown of the family name in science by articles, mostly on physiological optics, published in the *American Journal of Science*. Several of his educational addresses have also been published.

the North, as his brother did that in the South. Entering the corps of topographical engineers of the United States army, with the rank of captain, at the age of thirty-four, he remained in the Government service until 1831, attaining in 1828 the rank of brevet major "for ten years' faithful service."* His tastes were many sided, but his special studies—those which were the passion of his life—were in natural history. Before he entered the engineer corps he published a catalogue of the plants of New York city in the journal edited by the Dr. Hosack under whom his brother had studied medicine, and in subsequent years, during his connection with the army and afterwards, he published special studies on Utricularia, Gratiola, Ruellia, Tillandsia, Viola, and Pancratium, as well as our native grape-vines, tobacco, and pecan-nut. He published also a variety of papers on mammals, reptiles, batrachians, and crustacea, mostly of a systematic character, and collected a vast amount of original material for the natural history of our insects, as may be seen by a single installment, that was published in Paris in conjunction with Boisduval, upon North American butterflies. Coleoptera, however, may be said to have been his speciality, particularly in the lattter part of his career, though he published only four papers upon them, and mainly upon a single family, Histeridæ. He not only amassed a

* It is stated in some accounts of Major LeConte that have been published, and also in some manuscript notices I have seen, that Major LeConte entered the engineer corps in 1813 as one of the military engineers and that he projected or constructed several of the fortifications along the Atlantic sea-board, especially those about Savannah and at Old Point Comfort in Virginia (see Hist. Mag., V. 30). The army records, however, show that his commission bore date of April 18, 1818; that he was brevetted for "ten years' faithful service" April 18, 1828, and resigned August 30, 1831; furthermore, that he was attached to the topographical engineers, then distinct from the military engineers, and that his probable service in these works was the preliminary surveys which simply fixed the position and guided the construction of the fortifications themselves.

"Major LeConte was . . . about five feet six inches in height, with rather dark complexion, blue eyes, and aquiline nose. In disposition he was usually sociable and sufficiently communicative, but occasionally reticent and secluded, strong in his affections and aversions, and much beloved by his relatives whom he visited in Georgia. . . . For a number of years he was a member of the Episcopal Church, but he subsequently became a Roman Catholic, and in this faith he died."—Family records by Prof. LeConte Stevens. Dr. LeConte was brought up a Catholic, but after marriage attended the Protestant Episcopal Church.

considerable collection, but he left behind a most extensive series of water-color illustrations of our native insects and plants made with his own hands. It was natural, then, that his only child, upon whom he spent all his devotion, and whose mother had died when he was only a few weeks old, should share in these tastes of his father and almost sole companion.

Coming from such a stock it is not surprising that a decided taste for natural history, and even for the special branch entomology, in which he was engaged during an active life, should appear in the early youth of Dr. LeConte. He himself told how strong was his early passion while still at Mt. St. Mary's College. That it soon took the definite form of investigation is shown by the fact that while a medical student, at the early age of nineteen, he published his first paper, containing descriptions of twenty-odd species of Carabidæ from the eastern United States.

As must be the case with an intelligent student engaged in any branch of systematic zoölogy, his attention was quickly drawn to anomalies of geographical distribution, and we accordingly find him in one of his early papers drawing attention to several species of Coleoptera common to the North American and European continents, whose distribution could not be attributed to commerce; and in a brief but pregnant essay on the geographical distribution of Coleoptera in the northern part of our continent, appended to his contribution to Agassiz's "Lake Superior," distinguishing "the different kinds of replacement of species which are observed in passing from one zoölogical district to another," and nicely defining the distinction between "analogous" and "equivalent" species. "The prevailing character of tropical faunas," he says, "is individuality; the production of peculiar forms within limited regions; while the distinguishing feature of temperate and arctic faunas is the repetition of similar or identical forms through extensive localities." Such passages, written thirty-five years ago, mean far more than if first published now, and disclose a mind quick to grasp generalities, fertile in ideas, terse and discriminating in expression.

The subject of the faunal relations of animals was a favorite one with LeConte. He returned to it again and again; he was the first to district much of the vast and then almost unexplored regions west of our prairie country. The foundation of this work was laid in his essay on the distribution of California beetles, read to the American Association in 1851. With slight modifications the con-

clusions then reached were confirmed in his report of the Stevens division of the Pacific railroad survey, published in 1860; while in the same year a more elaborate and extended survey of the whole western country (excepting the then still unexplored region of the Great Basin) was given in his Coleoptera of Kansas and New Mexico. In this, following only in part the division suggested by Agassiz (who first laid down the primal geographical boundaries of North American faunas), he showed what remarkable differences were to be found within comparatively restricted areas in the western portion of our country, and laid the foundation for the special work that has since followed, in which the region here first mapped has been the point of greatest dispute.

He carried these studies a stage further when, in his presidential address to the American Association in 1875, he attempted, by collating the known facts concerning the actual distribution of certain of our Coleoptera which affect the seashore, but are also found in outlying spots upon the beaches of inland lakes, to prove the comparative antiquity of these forms; some of them, he endeavored to show, were unchanged survivors of species which lived on the shores of the cretaceous ocean when the Rocky Mountain and Appalachian districts were separated by a wide stretch of open sea, and other species were either older or somewhat less ancient. By investigations of this kind he hoped that we might recover important fragments of the past history of the earth, where the rocks disclosed no proofs. It must, however, be said that such propositions are to be considered speculative until supported here and there by the discovery of at least a few types from the tertiaries, if not from older rocks, identical with those now living upon the surface. It is not much to say that no such proofs have yet been found, for the careful study of fossil Coleoptera has scarcely more than begun, and of the numerous forms which have been exhumed in our own country at Florissant and other localities, already amounting to four or five hundred species of Coleoptera, very few indeed have been published. If, upon careful study, none out of this considerable number should prove identical with living types, and especially if species should occur nearly related to the forms specified by LeConte in the way of illustration, the force of the considerations presented by him will be weakened, and some modified explanation will be required of the anomalies of distribution to which he has called attention. For this we must await the results which are forthcoming. Meanwhile

the suggestions made in this address and the additions to them in his paper on Rocky Mountain Coleoptera in the "Bulletin" of Hayden's Survey in 1878, in which he expressed his belief that by careful studies of insect faunas in their totalities we shall be able to obtain a "somewhat definite information of the sequence, extent, and effect of geological changes in the more recent periods," are pertinent and, we may hope, will prove fruitful.

These contributions to zoo-geography, to which we have first called attention, were after all but accessories to his main work, the overflow of a mind charged with resources. Though in a very subordinate and imperfect way the key-note of his after work may be said to have been struck in his very first paper, in which he concentrated his attention upon a single group; and passing over his next, which is confined to miscellaneous descriptions, we come at once upon synopses and monographs of greater or less extent and value. It is not our purpose here to specially praise this early work, which no one knew better than he, or more freely acknowledged, was marked by crudity and inexperience; but we wish to call attention to the point that at the very outset of his career he was not carried away by the wealth of material at his hand into random publication of miscellaneous material, after the fashion of the day, but comprehended with scholarly instinct the far higher worth of symmetrical and co ordinated work and the training of his analytical powers. There was, therefore, from the first an orderly method in his work which shows itself even in his incomplete essays, and this was all the more remarkable from the fact, which cannot be too forcibly insisted upon, that previous to 1848, when his first so-called monograph appeared, there had been published by American entomologists three papers only of this character, all others having been mere catalogues or miscellaneous descriptions. One of these monographs was by Say on Cicindelidæ, published in 1817; the second by Major LeConte in 1845 on Histeridæ, and the third by Haldeman, as late as 1847, on the longicorn Coleoptera. LeConte, therefore, is seen to cut himself loose from the ordinary practice of his predecessors, and at once in this as in his geographical work to apply himself independently to the problems before him. How industrious he has been in this direction and what an influence he has exerted on the study of entomology in this country may be recognized by the mere statement that upwards of sixty monographic essays, some of them expanding to the form of a

volume, and all of them, after the first five years of work, direct and valuable contributions to the taxonomy of the order, have appeared from his pen.

We do not propose to analyze these, but only to call attention to two of the more important, and to point out that these monographic essays and synopses covered with fair equality the entire series of Coleoptera, as one may see by examining Henshaw's appendix to LeConte and Horn's "Classification of the Coleoptera of the United States," published last year. "They contain evidence," says his pupil and colleague, Dr. Horn, "of patient and original research and added greatly to science. His work was in every case an improvement on what had previously been done; he left a subject better than he found it."

These studies in the classification of the Coleoptera of our country culminated in a couple of remarkable works, published in 1876 and 1883, in each of which he was joined by his ardent coadjutor, Dr. Horn.

The first was a thorough monographic revision of the Rhynchophora or weevils of our country, forming an entire volume of the Proceedings of the American Philosophical Society, in which Dr. Horn elaborated a single family, the Otiorhynchidæ, while the remainder, or about three-fourths of the work, was prepared by Dr. LeConte. This memoir not only supplied a great need in American coleopterology, but it completely revolutionized the accepted classification of the day, and will make its way felt over a broader field than that it purported to cover. For LeConte, carrying out ideas which he had previously communicated to this Academy in 1867 and 1874, showed in this vast and inferior type of beetles the presence of characters, principally in the arrangement of the pieces on the under surface of the thorax, which isolated them completely from all other Coleoptera and allowed the use, in their subdivision, of characters drawn from quite different parts than were used in the subdivision of the normal series. The three great series which he thus established within the Rhyncophora were considered by him as the taxonomic equivalents of the six great groups, Adephaga, etc., in the normal series. Complaint has been made (from the other side of the ocean, of course) that such fundamental changes should not be "based upon the study, however accurate, of the fauna of a limited district or country," and entomologists are accordingly warned not to allow this essay "to disturb a generally accepted

classification." Such persons overlook the repeated statement of the learned authors that they have re-enforced their study of the American forms by the examination of many foreign types, and fail to notice that the principal novelty from which all the others sprang was announced years previous, allowing frequent opportunities to test the value of the proposed changes. It was a bold stroke, as Dr. Horn has pointed out, and it could not be expected that acceptance would at once be gained. The more closely it is examined the more rational does it appear, and we do not believe the day far distant when this as well as previous changes introduced by Dr. LeConte will find general acceptance.

The other work to which we referred, and which appeared only a few months before his death, was founded upon an uncompleted work which the Smithsonian Institution published in 1861, wholly his own, and which planned to give a general and systematic survey of all the genera and higher groups of North American Coleoptera. This first part included all the Isomera, excepting the Phytophaga, and was followed in the succeeding year by the Heteromera, the Phytophaga, generally classed in close proximity to the Rhyncophora, being still left untouched. When, in 1867, he had concluded on the absolute separation of the Rhyncophora from the other series of Coleoptera, he was free to carry out his unfinished work, and, in 1873, Crotch being then engaged in publishing a rapid series of synopses of the genera of our Chrysomelidæ, and Horn investigating the lesser family, Bruchidæ, LeConte took the remaining family, Cerambycidæ, in hand, and published a third installment of his classification. From this time until the monograph of Rhyncophora appeared he was engaged in the elaboration of that work. This finished, nothing remained but to complete the task to which he had pledged himself nearly a score of years before. To produce a homogeneous work, however, it was still necessary not only to revise much that had already been done, in the light of new material and the later investigations of others, but to break new ground as well over fields as yet comparatively untrodden.

A sense, however, of less enduring powers of work and the assistance, of which he gladly availed himself, which his colleague and former pupil, Dr. Horn, had rendered with such excellent results in the monograph of the Rhyncophora, led him to solicit anew the co-operation of Dr. Horn in the preparation of the monographic essays upon whose foundation it should rest, "hoping thereby to

lighten his own labor and prepare the work in a shorter time." How zealously Dr. Horn advanced to this work, his own thorough treatises, following rapidly one after the other, is sufficient proof; they are evidences not only of his industry and acumen, but of his loyalty to his friend and of the heartiness of his co-operation.

Three years ago, "when he realized that his health was failing, he expressed the desire," writes Dr. Horn, in his own modest account of their common task, "that I should join him in more active authorship in the work" which was to contain the final results of more than thirty years' systematic study of the Coleoptera of North America. "The first pages went to press in January, 1882, and the book was completed in March [1883], in time for him to realize that it had been at least well received. For obvious reasons," continues Dr. Horn, "I cannot dwell upon the merits even of his share of this work, except to say that his earlier edition is the basis of the present; without the former the latter might not have appeared. Evidences of his influence will be found on every page, and whatever it was my privilege to contribute was made possible entirely by his early instruction and guidance."

A comparison of the early and the later work, separated by an interval of over twenty years, is most instructive. The classification of Coleoptera, proposed by Olivier, founded primarily upon the supposed number of tarsal joints in the front and hind legs, was long so firmly established in entomological tradition, especially from the support given it by Latreille in his numerous general works, that it held some sway long after it was proved to be artificial. It served a useful purpose, however, in showing that this great assemblage of animals, of which more than a hundred thousand have long been known, was made up of a number of great series, or complexes, as LeConte called them, which, with some modifications of considerable importance, have been virtually accepted by entomologists for a long time. Their relative positions, however, and their equal or unequal taxonomic value have been a matter of considerable difference of opinion; there was a period of about a generation in length, previous to 1850, in which questions of this kind received a very large share of attention from leading entomologists, but the general consensus of opinion seemed to crystallize toward the view expressed by Lacordaire in his great work on the genera of Coleoptera, commenced in 1854, and this consensus was very closely reflected in the first edition of the "Classification of the

Coleoptera of North America"—not in any nomenclature of the complexes, for these were not even mentioned, but in the order in which the families followed one another. This succession was as follows: 1, Adephaga; 2, Clavicornia; 3, Lamellicornia; 4, Serricornia; 5, Heteromera. Beyond this, as stated earlier, the work did not proceed, as here, according to the accepted classification, the Rhynchophora were reached; but in 1873 the concluding part of the earlier edition was published, treating a portion of the Phytophaga, making them and not the Rhynchophora follow directly after the Heteromera, and so relegating this remaining complex to the last place.

This was the first serious disturbance of the accepted sequence of the complexes, and one upon which it would appear that LeConte's claim to highest distinction must ultimately rest with the world at large. It is much, very much, that the systematization of the vast array of Coleoptera of the United States may be said to be due wholly to his initiative and very largely to his personal studies and skill. But that he should venture to disturb fundamentally that system which had been the outcome of two generations of minute and patient investigation is, if it eventually stand the test of criticism, the work of a master hand. It goes without saying that he will never be forgotten for what he has done for his field of science in this country. It remains to be seen—for his prime work has still to stand the test of time—whether in future generations his fame shall be great elsewhere as here.

Consider now what must, in a sense, necessarily follow when a vast complex, like the Rhynchophora, is removed bodily from the midst of a series of complexes. It brings at once to the surface the question of the mutual relations of the great complexes hitherto separated by the Rhynchophora, and the whole fabric of classification must be narrowly investigated. And now begins the co-operative work of master and disciple, or rather we may now say the two colleagues, to which allusion was made in the quotation above from Dr. Horn's notice of Dr. LeConte. Hereafter we can speak of the work only as their joint production. Dr. Horn accepted fully in principle and in fact the views of Dr. LeConte concerning the Rhynchophora. Indeed, as Dr. LeConte states, the clew to his primary divisions of the Rhynchophora, proposed ten years ago, was given by an observation of Dr. Horn in his studies of certain Curculionidæ. These authors had together studied the structure and

discussed the relationship of a vast number of our Coleoptera; each was thoroughly acquainted with and had tested the value of the work of the other. In their two cabinets eleven thousand species of our beetles were at hand for verification of questionable points. What better opportunity could offer for such a joint work?

If now we compare the two editions of the work to see what changes were made, consequent upon the isolation of the Rhynchophora, we discover first of all that the Coccinellidæ and allied families are removed bodily from the Phytophaga with which they had from time immemorial been placed—a survival in fact of the purely tarsal system of classification—and placed in the Clavicorn series. This indeed had been done by Crotch in 1873 and 1874, but without defined reason, and working, as he did, side by side with LeConte and Horn, he doubtless shared their views of the Rhynchophora, and discussed with them the changes necessitated thereby. The remaining Phytophaga, including both the Longicornia and Chrysomelidæ, were placed before instead of after the Heteromera, as a part of the Isomerous series, and the relative position of the Lamellicornia was reversed—a return to the order of Latreille. The arrangement of the complexes, as it now appears in the "Classification" of Drs. LeConte and Horn, is as follows: 1, Adephaga; 2, Clavicornia (including Coccinellidæ, etc.); 3, Serricornia; 4, Lamellicornia; 5, Phytophaga (excluding Coccinellidæ, etc.); 6, Heteromera; 7, Rhynchophora.

These, however, are only changes in the grand relations of the great complexes. If we look more deeply we shall also find essential modifications in the minor arrangement of the families within the complexes, especially in the Clavicorn and Serricorn series, made necessary by the progress of investigation in all parts of the world, while other portions, like the Carabidæ, in the Adephagous series, have been altogether rewritten. As it stands, the work is the last expression of science regarding the classification of Coleoptera, and must exert a wide and powerful influence on the study of this great group, not in this country only, but throughout the world, especially wherever students are dealing with the beetles of the temperate zones. As Mr. A. Matthews has said: "The comprehensive lines on which it has been constructed will include (with, it may be, trifling modifications) the Coleoptera of both sides of the world." We think we can say unhesitatingly that very few, if any works, dealing with large groups of animals have been produced in this country—per-

haps none, if we except those of Professor J. D. Dana—which have had so much influence on the views of naturalists the world over upon the classification of the group concerned as this is sure to have, and we look confidently to the future for the verification of our judgment.

We have specified in some detail these two works of Dr. LeConte because they are the most extensive and the latest, and because they represent the others, summing up in a sense the investigations of an active, studious life. They everywhere bear the marks of a master, and none the less that he associated with himself one, much younger than he, who had been his pupil. This, too, is the mark of a master. There is no need, therefore, nor have we time, to pass in review the separate monographs and other papers upon Coleoptera which flowed from his pen. It is sufficient proof of his industry to point out that nearly half of our Coleoptera have been described for the first time by him (he has actually described or at least named 4,739 nominal species), and that in his works will be found original definitions of more than 1,100 of the higher groups, besides nearly 250 synoptic or analytic tables, some of them several times remodeled.*

These entomological studies, while they formed the principal features of LeConte's scientific life, were not the only ones which enjoyed his attention; for the liberal training he received, the paternal example, and his own general receptivity made him at home over much wider fields. One of his earliest papers was upon a mineralogical topic, and between 1848 and 1857, the ten most prolific years of his life, so far as the mere number of papers is concerned, he published various minor essays on geology, radiates, recent and fossil mammals, and ethnology, indicating the activity of his mind in many directions; and his general papers on various occasions, as well as his conversation, showed his familiarity with the advance of science in all directions.

That LeConte was the greatest entomologist this country has yet produced is unquestionable. *Facile princeps* will be the universal judgment both now and by posterity. His worth was early recognized. European entomologists who crossed the ocean paid

*An index to the Coleoptera, described by Dr. LeConte, has been published by Henshaw (Trans. Am. Ent. Soc., IX, 197), who also compiled, several years since, a list of his entomological writings (152 numbers, since increased to 180) which was published as the first of Dimmock's Special Bibliographies, issued with *Psyche*, Vol. II.

him their first visit; and all, charmed with his learning and affability, and the freedom with which he communicated his rich stores of knowledge, always spoke with enthusiasm of his erudition and his generous and simple spirit. It was the same on his visits abroad. His minute familiarity with all the details of structure through long series of varied degrees of complexity, his wonderfully retentive memory, his quick and accurate judgment, his courage and self-reliance, all gave his words weight, and his counsel and opinion were eagerly sought by his confreres. This is further shown by the fact that he was received into the limited circle of recipients of honorary membership in all the older and larger entomological societies of Europe.*

On several occasions, it was my chance, while in Europe, to follow in his steps, and it was always to find those who had seen him most hearty in his phrase. "No one who ever knew him," writes one after his death, "could fail to be fascinated by the amiability of his disposition, his universal knowledge, and surpassing intellect." There was a quiet ease and dignity in his person, which, while it in no wise hindered approach, gave evidence of a reserve of force and of a confidence not easly shaken. I remember well with what timidity I, an utter stranger, a mere boy, first ventured to seek him, a man but twelve years my senior, yet clothed with all the garb of learning—and with what kindness I was received and counseled. The pains he took for others, the time he has given, the immense labor he has undertaken in determining series of beetles for a hundred correspondents all over the country can never be known. The signs of it appear in all the entomological literature of the United States and Canada.

LeConte was not a man of many words; his language was precise and vigorous, and his style perhaps a little scholastic for these later days; at all events it was a style so individualized that I do not think he could have hidden the authorship of a letter or an essay he had written. He was of a philosophic turn of mind, and, with

* LeConte was a corresponding or honorary member of more than thirty societies, about equally distributed between this country and Europe. He was also one of the founders of the American Entomological Society. He was elected, in 1874, to the presidency of the American Association for the Advancement of Science, and at the time of his death had been several years a vice-president of the American Philosophical Society. He was a charter member of this academy.

a strong natural conservatism, was yet open-hearted to the truth. He accepted, rather preached, the modern evolutionary philosophy, but had little patience with those who looked upon this as a means of ridding the world of an intelligent control of "the Providence," as he expressed it, "which presides over and directs the system of evolution." Cautious and never destructive in the tendencies of his thought, he abhorred the crude speculations, whether of the irreverent or bigoted mind. "Let not our vanity," said he, "lead us to believe that, because God has deigned to guide our steps a few paces on the road of truth, we are justified in speaking as if He had taken us into intimate companionship and informed us of all His counsels." Those who knew him better than I can speak better of his personal worth. They have spoken, and they but reflect the feelings a less intimate acquaintance has given me. "We all knew him," writes one, "as a cultured scholar, a refined gentleman, a genial companion, a true friend. To me he was more." It is his colleague, Dr. Horn, who is speaking. "Our friendship ripened to an intimacy never shadowed by the slightest cloud." "Let the world reverence his memory as a discoverer," says Professor Lesley, his life-long friend, "as a philosopher, as a genius. I can only remember [him] as an engaging friend, a faithful friend, a speaker of the truth, a judicious adviser, a companion to think with, a reliable coadjutor to deal with, but still, above all, as a most affectionate and trustworthy friend."

APPENDIX ON THE ANCESTRY OF DR. LeCONTE.

As the tracing of the pedigree of Dr. LeConte has been attended with some difficulty, and I have reached some conclusions at variance with family traditions, I have ventured to think that its publication may not be without interest. To enable my statements to be verified I append in a note* the sources of information that have been open to me, which are referred to throughout by the numbers prefixed to them; and in doing so I must return cordial thanks to those who have assisted me with original material. First, to Mrs. LeConte, who kindly placed in my hands all the documents bearing on the subject which were in the possession of Dr. LeConte, including the manuscript genealogical notes collected by his father, Major LeConte; second, to Prof. Walter LeConte Stevens, who has permitted me to use and publish what I wished from a MS. family record of great interest—a permission of which I have gladly and freely availed myself, both here and in the body of this article; third, to Rev. Chas. W. Baird, who has generously given me, from original data, many useful clews to the early history of the Huguenots in America, which he has collected at great pains; and fourth, to Prof. Joseph LeConte, who has given me many details, particularly with regard to the California members of the family.

It has long been a tradition in the LeConte family that they were descended from one Guillaume LeConte, who was with the Prince of Orange in Holland and England; came to this country toward the end of the seventeenth century; settled in the Huguenot colony at New Rochelle, near New

*1. Manuscript notes by Major J. E. LeConte.
2. Manuscript notes by Rev. C. W. Baird from original records.
3. Family records of the LeConte family (MSS.) by Prof. W. LeConte Stevens.
4. Manuscript notes by Prof. Joseph LeConte.
5. " entries in the old Elzevir Bible owned by Dr. LeConte.
6 " notes of Dr. J. L. LeConte.
7. " documents in State Archives, Albany.
8. Marriage licenses of New York previous to 1784 (Albany, 1860).
9. New York Genealogical Biographical Record. Vol. II (O'Callaghan), 1871.
10. Historical Magazine, Vol. V (New York), 1860.
11. Bolton's History of the Protestant Episcopal Church in the county of Westchester, New York, 1855.
12. Bolton's History of the county of Westchester, two vols., New York, 1848.
13. Wicke's History of Medicine in New Jersey. Newark, 1879. Based on MS. notes Prof. John LeConte.
14. Sharswood's Life of Major LeConte (Stett. ent. Zeit.).
15. Documentary History of New York. Four vols., Albany, 1850–1851.
16. Colonial History of New York. Fourteen vols., Albany, 1856–1883.
17. Stevens' History of Georgia. New York, 1847.
18. Calendar of Historical MSS. in Secretary of State's office at Albany. Part II, Albany, 1866.
19. Baird's History of the Huguenot Emigration to America. Two vols., New York, 1885.

[A few changes have been made in the original of the appendix since the appearance of this History.]

York city; and married a Marguerite de Valleau, of Martinique (the date of the marriage being exactly given), through whom the descent came. It has also been claimed that two others of the same name, his nephews, came over with him and with the Chevalier DeLancy, who landed in New York July 7, 1686.

In a "list of Huguenots of the colony at New Rochelle," however, which Dr. LeConte had in his possession, and the exact origin of which is unknown, we find the following names: François LeConte, Isaac LeConte, Jaques LeCompte, Jacques LeConnet, Guillaume LeConte, Pierre LeConte, and Henri LeConte, seven names. As the list includes 371 names of males alone, and the name of Etienne Delancy among others enters it, while the census of 1710 give only 67 "male Christians" at New Rochelle, it is evident that the list includes all the Huguenots of the region about New York.

In any case we have here to deal with six LeContes, provided we look upon Jaques LeCompte and Jacques LeConnet as the same, as we perhaps may. But in truth we have a record of two more in this region before 1700: Thomas, who, like Henri mentioned in the list, is the reputed nephew of Guillaume, and came over with DeLancy in 1686, and John, Jean, or Johannes, to whom letters of denization were granted in New York July 29, 1686 [7], and who was probably the brother of Pierre. That John is not mentioned in the list indicates, it appears to me, that the list is ancient and independent, for repeated records of John are to be found which would not have escaped a search among documents.

We have then (I) Jacques, of New Rochelle, whose birth-place is unknown, who was perhaps the brother of II, and the first record of whom we find in 1691, but in a document which makes it appear probable that he was in New York or the West Indies in 1689. (II) François, of New Rochelle, formerly of Port L'Evéque, perhaps brother of I, whose marriage is on record as taking place in New York in 1693 [2]. (III) Pierre, of Staten Island, born in Dieppe, probably the brother of IV and possibly of VIII, and naturalized in New York September 27, 1687 [2]. (IV) Jean, probably brother of III, naturalized in 1686 [7, 19]. (V) Isaac, mentioned above, of whom nothing more has been discovered. (VI) Thomas, of New York, originally from some place in Normandy, brother of VII and nephew of VIII, who is supposed to have arrived with DeLancy in 1686. (VII) Henri, of New York, from Normandy, brother of VI and nephew of VIII, who is supposed to have come over with DeLancy, and of whom we have record as a lieutenant of a foot company in New York before 1691 [7]. (VIII) Guillaume, of New York, formerly of Rouen, possibly the brother of III and the uncle of VI and VII, whose name we first find on documents in 1702. The descendants of these are recorded in order further on.

In the above I have distinguished between I and VIII by calling one Jacques and the other Guillaume, as in the list of Huguenots. Heretofore they have been taken for the same person, and called indifferently Jacques, Guillaume, and William. That they are two personages seems highly probable, and as it is from one of them that the family we are interested in has

descended, I have spared no pains to determine the point. The evidence is as follows:

I a. Guillaume LeConte is found in the list of Huguenots arriving in New York from St. Christopher and Martinique in November, 1686 [19].

I b. In the State Archives at Albany, among the historical documents, Vol. XXXVII, f. 247, we find a petition with the signature—

asking that letters of administration be given to him on the estate of "mr. James Laty his father in Law" who died since he had given a "Letter of atturney made and written at the Island of St. Christophers bearing date the 16th of March 168$\frac{8}{9}$." The petition was granted September 9, 1691. His wife's name, therefore, was Laty. This I take to refer to I:

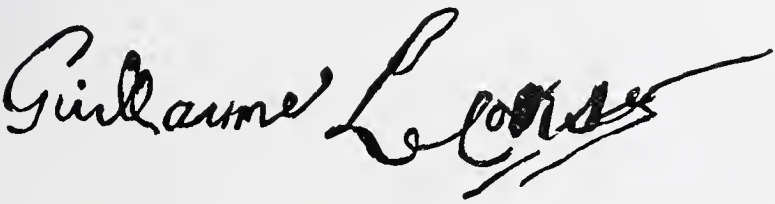
I c. In the "List of the towne of New Rochelle &c XBr 9th 1710" [15] the names of the inhabitants are evidently given by families, in which the father's name is placed first, next the mother, followed by the children, where, excepting in cases of great disparity, the boys precede the girls. In this list we have two LeConte families, as follows, the figures giving the ages: William LeConte, 52; Mary LeConte, 42; William LeConte Jr., 16; Hester LeConte, 17; Jean LeConte, 6; ffrancis LeConte, 45; Mary LeConte, 55; Josiah LeConte, 13; Mary LeConte, 18. Supposing the older William to be the same as the Guillaume (=Jacques, I) of the preceding paragraph, he was born about 1659, his wife (Mary Laty) about 1669, his oldest son (William) about 1695, his oldest daughter (Hester) about 1694, and his youngest son (Jean) about 1705.

II a. The ancestor of Dr. LeConte (VIII) is stated in the family traditions to have been in the army of William III when in Ireland in 1690, and to have afterwards emigrated to this country. It is therefore highly improbable that he was given a letter of attorney at St. Christophers in 1689.

II b. The traditions also state especially with date (February 16, 1701) his marriage to Marguerritte de Valleau, of Martinique; whereas in 1710 the living wife of I was named Mary.

II c. The marriage license of "William LeConte and Margaret Mahoe," April 17, 1703, is on record in New York (Office of Surrogate. Wills. lib. VII, p. 100) [2]. This again could not refer to I.

II d. The will of "Guillaume LeCounte," with the signature as follows:



is also on record at the same office. It mentions his "deer wife Margarita," and names three children: Guillaume, Esther, and, toward the end of the will, Pierre. The will was acknowledged and proved March 2, $17\frac{10}{11}$. As we have the dates of the births of all these children, we may conclude that in 1710, that is, at the time of the census of New Rochelle above mentioned, the two families we are attempting to separate stood thus:

I		VIII	
Jacques LeConte	æt. 52	Guillaume LeConte	æt. 51
Mary Laty (his wife)	" 42	Margaret Mahoe (his wife)	" ?
Children.		Children.	
Hester	æt. 17	William (by former wife)	æt. 7
William	" 16	Pierre	" 6
Jean	" 6	Esther	" 4

This seems the only way to settle the otherwise conflicting evidence, and when we consider that these two men, of the same age, emigrating to New York at about the same time, each having three children, of whom two were named William and Hester (or Esther), it is certainly not surprising that they should have been confounded. The only difficulties in the way are the considerable resemblance of the two signatures (considering the interval of about twenty years between them), and the fact that Mrs. Dr. LeConte does not recognize in the seal attached to Guillaume's will above mentioned any now in her possession said to have descended from him. This seal gives a full-length effigy of a knight in armor on a rectangular plate surrounded by cloud-like ornaments. But the fact that different seals exist which have descended from him renders this fact of less importance.

It might also be added that there are several other unaccountable facts which affect the early history of the LeContes. I have mentioned that the names of only two families occur in the census of New Rochelle in 1710, although all the original LeContes with whom we are concerned came over to New York and vicinity before or about the year 1700. There is also another list of New Rochelle inhabitants, said to be of the year 1698, but more probably belonging to 1712 (N. Y. Coll. MSS. XLII, f. 59), in which no LeContes at all are mentioned, although 188 whites between the ages of 1 and 67 are given. Nor does the name occur in a similar list of 517 persons (including about 220 white males) of Westchester county (*ibid*, f. 60). Nor in the census of the city of New York "about the year 1703," where all the "masters of familys" are entered (Doc. Hist. N. Y. I, 611-24).

My own brief reseaches having brought out so many facts I can hardly doubt that a closer investigation of early State and ecclesiastical documents will determine very certainly the relations of all the parties concerned. On the conclusions given above as a basis the following tables of lineage are presented:

Jacques b. 1658, m. Mary Laty, of St. Christopher (b. 1668) [7, 15].
Hester b. 1693, m. Ezechiel Bonyot (nat. Ap. 21, 1719) [2, 15].

[Children of Hester (b. 1693).]
Marianne bap. Feb. 5, 1719 [2].
Esther " Aug. 25, 1717 [2].
Ezechiel " Dec. 16, 1719 [2].
Marie " Ap. 30, 1721 [2].
Guillaume b. 1694, m. Annette Martha ——— [7, 12].
Francis m. ——— [12].
Paul d. 1815 [12].
Josiah m. Anne Riché [12].
John m. (lic. Jan. 9, 1756) Catharine Van Horne [9, 12].*
Thomas [12].
John m. Hannah Ferris [12].
Samuel [12].
Hannah [12].
Eleanor [12].
Joseph m. Hannah Raymond [12].
Platt [12].
Francis [12].
Joseph [12.]
Elizabeth [12.]
Josiah m. i., Mary Angevine; ii (lic. Oct. 29, 1762), Susannah Souliee [8, 12.]
Peter, lost at sea [12.]
John m. Sarah Badeau [12.]
Josiah [12.]
William [12.]
John [12.]
Mary m. Nathaniel Lawrence [12.]
Jean b. 1705; commiss. on part of gen. ass. 1736; memb. gen. ass. from Richmond Co. 1750; d. early in 1756; m. ——— [2, 15, 18.]
John m. without license in Jan. 1756 [18.] †
François b. 1666, at Port L'Evéque (son of François LeCompte and Marie Amon); m. May 31, 1693, Catherine Lavandier, wid. Daniel Marchand; victualler; nat. Ap. 18, 1695; was living in 1710 [2, 11, 15, 19.]
Marie b. 1693 [15.]
François b. Mar. 2, bap. Mar. 4, 1694; moved away from New Rochelle before 1710?; was living there in 1762 [2, 11, 15, 19.]
Josias b. Feb. 20, bap. Feb. 21, 1697; m. Esther Besly, da. Olivier and Susanne Besly; was living in 1743 (see below under Susanne, grandda. Guillaume) [2, 11, 19.]
Judit b. Dec. 18, 1729, bap. Jan. 25, 1730 [2.]

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*Bolton makes this John to have married Catharine, but it is impossible that he should have been married when his great-grandfather was only 62 years old; another John is certainly meant. It is indeed far more likely that it was his great-grandfather's brother Jean's son John. (q. v.)

† Perhaps it is this John who afterwards married with a license, Oct. 29, 1762, Susannah Soulice (see also note above).

[Children of Josias (b. 1697), continued.]
François b. Feb. 14, 1732, bap. April 7, 1732; sponsors Olivier and Susanne Besly [2.]
Josias m. Susannah Bertain, da. Peter and Catherine Bertain [2.] *
Susannah b. March 11, 1751, bap. March 31, sponsors Josias LeConte senr. and Cath. Bertain [2.]
Peter b. Feb. 12, 1753, bap. March 11, 1753, sponsors Peter Bertain and Esther (Besly) LeConte [2.]
Madeleine, b. March 15, bap. March 20, 1698, d. before 1710 [2, 15, 19.]

PIERRE b. at Dieppe, nat. Sept. 27, 1687, d. 1704; m. Margaret ——— [2, 12, 19.]
Jean [12.]
Pierre [12.]
Jacques [12.]

JEAN nat. July 29, 1686, d. 1697; m. Hester Lakeman (da. Abraham Lakeman, d. about 1702; exec. of will were Peter LeConte and Abraham Lakeman) [7, 12, 19.]
Susanne b. about 1696 [7, 19.]

ISAAC.

THOMAS m. i, Gertrude van Hoorn, of Staten Island; ii, Elizabeth Broome, of New York; had no children [1.]

HENRI m. Aug. 5, 1686, Grace Walroud, da. George Walroud, of Barbadoes [1, 2.]
Walroud b. July 30, 1691, d. Aug. 5, 1692 [1, 2.]

GUILLAUME b. at Rouen March 6, 1659, d. at New York, Sept. 15, 1720; m. i, Feb. 16, 1701, Margueritte de Valleau, da. Pierre Joyeulx de Valleau, of Martinique; d. between Dec. 3, 1702, and April, 1703 [1, 3, 4, 6.]
William b. Dec. 3, 1702; lieut. militia company at New Rochelle 1740; d. 1760; m. Anne Elise (Marianne) Beslie [1, 3, 4, 6, 7, 13.]
Anne bap. Oct. 23, 1733, sponsor her aunt Esther; m. April 14, 1764 (lic. July 1, 1763), Peter Flandreau [1, 2, 3, 8.]
A daughter [1.]
Susanne bap. Feb. 8, 1727, sponsor Pierre LeConte (brother or uncle?); m. William Bayly, brother of Olivier Besly (see above under Josias, son of François) [2, 3, 6.]
William LeConte b. Aug. 8, 1745, bap. Aug. 25, 1745, sponsors William LeConte grf., Olivier and Susanna Besly, uncle and aunt; m. Sarah Pell, da. Joseph Pell, 3d Lord of Pelham manor [2, 3.]
Susanne.

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† Peter and Catherine had another daughter, Catherine, who married Isaac Sicard about 1750 [2.]

[Children of William LeConte (b. 1745), continued.]
William LeCompte.
Joseph.
Ann Bayley m. Capt. James Hague.
James.
William D. D. Baptist clergyman b. about 1805.
John Bayley.
Glorianna.
Joseph.
Richard (Bailey) b. 1745,? surg. Engl. army; m. i, Mrs. Post, née Charleton, no issue (child by former marriage Dr. Wright Post); m. ii, Charlotte Amelia Barclay [3.]
Child, name unknown [3.]
Eliza Ann (Elizabeth) m. ——— Seton,? known as "Mother Seton" [3.]
Richard [3.]
Barclay [3.]
William [3.]
Guy Carleton m. Grace Roosevelt [3.]
James Roosevelt, Archb. Baltimore [3.]
Richard [3.]
Guy Carleton [3.]
William [3.]
——— m. ii, April 17, 1703, Margaret Mahoe [Mahant], of New Rochelle, d. Sept. 15, 1720 [2.]
Pierre M. D. b. July 25, 1704, bap. Dec. 10, 1704, by Rev. Mr. Bondet, spons. Philip Cazier and Mary Vergereau, née Mahant; d. Jan 29, 1768, at Matawan, N. J.; m. i, March 18, 1733, Margaret Pintard (d. Jan. 30, 1736) by Rev. Gerardus Haerghoordt, no issue; m. ii, Jan. 9, 1737, by Wm. Brimley, j. p., Valeria Eatton (b. Shrewsbury March 17, 1715, da. John Eatton and Joanna Wardle, of Eattonville; d. 1788 in Orange) [1, 2, 3, 4, 5, 6, 13.]
William b. March 20, 1738, bap. April 12, 1738, by Rev. J. Mills; spons. fath., moth., and Joseph Eatton; d. Savannah Nov. 4, 1788; m. May 6, 1782, Elizabeth Lawrence [1, 3, 4, 5.]
John Eatton b. Sept. 2, 1739, bap. Nov. 25, 1741, by Rev. W. Tennant; d. New Jersey Jan. 11, 1822; m. 1776, Jane Sloan [1, 3, 4, 5.]
William b. March 4, 1777; d. at New York October 23, 1807 (1806? —1, 3, 4, 13) [5.]
Louis b. Shrewsbury, N. J., Aug. 4, 1782; d. Jan. 9, 1838; m. in Georgia Jan. 30, 1812, Ann Quartermann, b. Oct. 26, 1793; d. Dec. 24, 1826 [1, 3, 4, 5, 13].
William b. Liberty Co., Ga., Nov. 18, 1812; d. Jan. 25, 1841; m. Nov. 10, 1833, Sarah A. Nisbet [3, 4].
James Nisbet m. Mary Gordon [3, 4].
Ann m. Clifford Anderson [3, 4, 13].

[Children of Ann, daughter of William (b. 1812), continued.]
Sarah Nisbet [3].
Halbert [3].
William LeConte [3].
Clifford [3].
James LeConte [3].
Louis Joseph [3].
Mary Lee [3].
Anne [3].
Robert Lanier [3].
Ophelia [3].
Custis Nottingham [3].
Laura Boykin [3].
Ethel [3].
William Louis m. Virginia Trimble [3].
William Louis [3].
James [3].
Nisbet [3].
Sarah Ophelia m. Frank H. Stone [3].
Charles [3].
William [3].
Henrietta [3].
Sarah Ophelia [3].
Anna Louisa [3].
Frank LeConte [3].
Clifford [3].
Mary [3].
Josephine [3].
Walker [3].
Jane b. Woodmanston, Ga., Nov. 23, 1814; d. San Francisco, Oct. 28, 1876; m. Dec. 12, 1833, John M. B. Harden, M. D. [3, 4].
Lewis LeConte d. 1839? [3, 4].
Matilda Jane m. T. Sumner Stevens [3].
Annie Rosa [3].
John LeConte m. Anne Way [3].
Louis LeRoy [3].
William Sumner [3].
John Samuel [3].
Ada Rosalie [3].
Mary Lillian [3].
Anne Eliza m. C. B. Adams M. D. [3, 4, 13].
Cornelius [3].
David [3].
John Harden [3].
Ada Louisa [3].

[Children of Louis (b. 1782), continued.]

Elizabeth b. 1816, d. 1818 [3, 4].

John b. Woodmanston, Ga., Dec. 4, 1818; m. July 20, 1841, Eleanor Josephine Graham, b. New York, Nov. 22, 1824. [3, 4].

Mary Tallulah b. Savannah, Ga., Feb. 23, 1843; d. Columbia, S. C., March 21, 1868 [4].

Louis Julian b. Savannah, Ga., March 3, 1845; m. 1880, Oakland, Cal., Mary Harmon [4].

John Cecil b. Athens, Ga., Jan. 25, 1850; d. Oakland, Cal., Nov. 19, 1874 [4].

Lewis b. Woodmanston, Ga., Jan. 7, 1821; d. Oct. 20, 1851; m. July 25, 1843, Harriet Nisbet.

Harriet Eveline [3].

William d. Nov. 4, 1876 [3].

John Nisbet [3].

Louis Eatton m. Caroline Adams [3].

Eva [3].

Caroline [3].

Joseph b. Woodmanston, Ga., Feb. 26, 1823; m. Jan. 14, 1847, Caroline Elizabeth Nisbet, b. at Athens, Ga., Jan. 1, 1828 [3, 4].

Emma Florence b. Milledgeville, Ga., Dec. 10, 1847; m. 1869, Farish C. Furman [3, 4].

Katherine Carter [3].

Elizabeth Nisbet [3].

Sarah Elizabeth b. Cambridge, Mass., Nov. 11, 1850; m. 1877, Robert Means Davis, of So. Carolina [3, 4].

Joseph LeConte [3].

Henry Campbell [3].

Robert Means [3].

Isabel b. 1884 [4].

Josephine Eloise b. Columbia, S. C., Sept. 20, 1859; d. Sept. 12, 1861 [4].

Caroline Eatton b. Columbia, S. C., Nov. 3, 1863 [4].

Joseph Nisbet b. Oakland, Cal., Feb. 7, 1870 [4].

Anne b. Woodmanston, Ga., March 26, 1825; d. Sept. 2, 1866; m. June 8, 1843, Dr. Josiah Peter Stevens, b. Nov. 17, 1818 [3, 4].

Ella Florine b. Woodmanston, Ga., Feb. 1, 1845 [3].

Walter LeConte b. Gordon (then Cass) Co., Ga., June 17, 1847 [3].

Josiah Perey b. Lumpkin, Stewart Co., Ga., March 23, 1852; m. Jeannie Alexander [3].

Louis Oliver b. Walthourville, Liberty Co., Ga., March 1, 1856 [3].

[Children of Anne (b. 1825), continued.]

Anna Louisa b. Baker Co., Ga., Aug. 21, 1860; d. Oct. 4, 1867 [3].

Mabel Caroline b. Walthourville, Ga., July 30, 1862; d. Decatur, Ga., Aug. 31, 1874 [3].

John Eatton b. Shrewsbury, N. J., Feb. 22, 1784; d. Philadelphia, Nov. 21, 1860; m. July 22, 1821, Mary Anne Hampton Lawrence, da. Jonathan Hampton Lawrence and Joanna Blanchard [1, 2, 3, 4, 5].

Edward b. May 10, 1822; d. Feb. 9, 1823 [1].

Edward b. Nov. 5, 1823; d. Jan. 25, 1824 [1].

John Lawrence b. New York, May 13, 1825; d. Philadelphia, Nov. 15, 1883; m., Philadelphia, Jan. 10, 1861, Helen S. Grier, da. Hon. Robert C. Grier and Isabella Rose [1, 3, 5.]

John Eatton b. Jan. 17, 1862; d. May 19, 1885 [5.]

Isabella Rose b. July 10, 1863, d. Aug. 26, 1863 [5.]

Robert Grier b. July 17, 1865 [5.]

Margaret b. July 11, 1741, bap. Nov. 25, 1741, by Rev. W. Tennant; d. Sept. 9, 1812; m. Rev. Jedediah Chapman, who was b. Sept. 27, 1841; d. May 22, 1813, and by first wife, Blanche Smith, had William Smith, Robert Hett, John Hubbard [5, 13.]

Peter LeConte b. Jan. 8, 1778, d. Sept. 17, 1836; took name of LeConte and m. Jerusha Bishop (the following from History of the Chapman family).

Margaretta b. July 19, 1806, m. Abraham Myers.

LeConte.

Gustavus Adolphus.

William b. June 5, 1808, d. Dec. 12, 1850.

Chlorinda b. April 16, 1810, d. July 17, 1842; m. April 25, 1839, George Miller (no issue).

Mary b. Aug. 28, 1812.

Robert b. Jan. 23, 1815, d. Nov. 30, 1842.

Porter [Rev.] b. Feb. 27, 1817, d. Aug. 16, 1847; m. Sept. 24, 1846, Anna Brooks (no issue).

Caroline b. Sept. 28, 1819; m. May 1, 1849, Cornelius V. H. Morris (one daughter).

John Thomas b. April 24, 1779; m. Elizabeth Tooker (nine children)

Valeria Maria b. ——, d. Oct. 31, 1847; m. Oct. 11, 1808, James Reynolds (four children).

Thomas b. June 23, 1747, bap. July 26, 1747, by Rev. W. Tennant; d. Georgia, Sept. 27, 1770 [1, 5.]

Peter b. April 13, 1751, bap. May 19, 1751, by Rev. W. Tennant; d. Georgia, Nov. 23, 1776 [1, 3, 4, 5.]

Esther b. July 6, 1706 [1, 6.]

There are also records of the following marriages which I cannot place:
Boudewyn LeConte and Elsie Frederick, lic. May. 14, 1756 [9.]
Sarah LeCont and John Sternberg, lic. Oct. 20, 1763 [8.]

The descent of Dr. LeConte on his mother's side—a Lawrence—is as follows: William Lawrence, who died in 1680, married Elizabeth Smith. Their son Joseph had a son Jonathan, who was born in 1690 and died in 1775. His son Isaac, born in 1729 (d. 1781), married Mary A. Hampton. Their son Jonathan Hampton (b. 1763, d. 1844), married Joanna Blanchard, and had Mary Anne Hampton Lawrence, who married Major LeConte.

The foregoing biographical sketch was also printed, with a portrait of Dr. LeConte, in the Transactions of the American Entomological Society, Vol. XI, 28 pp.

The following notices of Dr. LeConte have been published elsewhere:

By J. P. Lesley and G. H. Horn, Proc. Amer. Phil. Soc. XXI, 291-299.
[By H. A. Hagen], Proc. Amer. Acad. Arts Sc., XIX, 511-516.
By C. V. Riley, Psyche, IV, 107-110.
By F. G. Schaup, Bull. Brookl. Entom. Soc., VI, No. 8; accompanied by a portrait and bibliography, 9 pp.
By A. Sallé, Ann. Soc. Entom. France, April 1884, 6 pp.

MEMOIR

OF

JOSEPH JANVIER WOODWARD.

1833-1884.

BY

J. S. BILLINGS.

READ BEFORE THE NATIONAL ACADEMY, APRIL 22, 1885.

BIOGRAPHICAL MEMOIR OF JOSEPH JANVIER WOODWARD.

Dr. Joseph Janvier Woodward, Surgeon and Brevet Lieutenant Colonel U. S. Army, was born in Philadelphia October 30, 1833, and died near that city on the 17th of August, 1884. He was educated at the Philadelphia Central High School, from which he received the degree of A. B. in 1850, and that of A. M. in 1855, when he was honored with the position of valedictorian of his class.

He commenced the study of medicine in the office of Professor George B. Wood, attending lectures at the same time in the University of Pennsylvania, from which he received the degree of M. D. in 1853. He then opened an office for the practice of medicine in Philadelphia, gave private instruction in the use of the microscope and in pathological histology, and was a prominent member of the Pathological Society. At this time, in connection with the late Dr. Charles Bishop, he carried on a large quiz class in connection with the course of instruction in the University of Pennsylvania. He was demonstrator in operative surgery at the University of Pennsylvania; clinical surgical assistant to Professor H. H. Smith, and in charge of the surgical clinic of the University. At the outbreak of the war he at once offered his services to the Government and entered the army as assistant surgeon, his commission dating August 5, 1861. His first service was with the Second Artillery in the Army of the Potomac. May 19, 1862, he was assigned to duty in the Surgeon General's Office at Washington, in which position he remained until his death. In conjunction with Dr. John H. Brinton, of Philadelphia, he was assigned to the duty of collecting materials for a Medical and Surgical History of the War and for a Military Medical Museum. At the end of the war he was placed in charge of the pension division of the Surgeon General's Office, of the medical collection of the Army Medical Museum, and of the preparation of the medical portion of the Medical and Surgical History of the War. Soon after his assignment to duty in Washington his atten-

tion was attracted by the results of some experiments in photo-micrography made by Dr. William Thomson, now of Philadelphia, who was at that time in charge of one of the Washington hospitals, and appreciating the importance of perfecting this means of obtaining accurate representations of pathological histology he at once took the matter up, and with the assistance of Dr. Edward Curtis, U. S. Army, proceeded to improve the old and to devise new methods for this class of work. This led to the endeavor to secure improved objectives especially adapted to photo-micrographic purposes, and to the use of this process as a means of testing with scientific accuracy the relative merits of different objectives.

His publications of the results obtained by work in this direction gave a powerful stimulus to those engaged in the construction of microscopic objectives, and the great improvements which have been made in these instruments of research during the last twenty years have been due to a very considerable extent to his labors.

The essential features of the photo-micrographic processes used by him or under his direction at the Army Medical Museum were the use of a dark room so arranged that the operator was, so to speak, within his camera, the use of monochromatic light and of lenses specially adapted to it, and the great care and skill with which the dry and water immersion lenses of high power and the means of illumination were adjusted to produce the best possible results.

With the introduction of homogeneous immersion lenses much of the labor previously required became unnecessary, but the patience and skill with which Dr. Woodward adjusted his apparatus so as to produce the best possible results of which it was capable, were unequaled by any of the microscopists of his day.

His contributions to medical and scientific literature were numerous and extensive, as will be seen by the list appended to this sketch. The most important of these are the two volumes of the Medical and Surgical History of the War which he prepared, the reports on cholera and yellow fever in the Army of the United States published in 1867 and 1868, and the series of reports, with photographs, on the application of photo-micrography to test objects and to histological work. In 1873 he was elected a member of the National Academy of Sciences, in which he took a deep interest, and for which, as a member of various committees, he did much valuable work. As a scientific investigator and thinker his especial characteristics were the incessant labor which he devoted to the subjects

on which he was engaged and his desire to obtain his data at first hand as far as possible. His turn of mind was essentially that of a critic, and his first impulse on hearing of any alleged new fact or observation relating to matters in which he was interested was to doubt, and to attempt to verify it for himself. As a specimen of this class of work reference may be made to his numerous and interesting bibliographical notes contained in the medical volume of the second part of the Medical and Surgical History of the War. He was a clear and logical thinker and took great delight in communicating his views and opinions at all times.

In the circular announcing his death the Surgeon General says:

"With such a record it is needless to speak of his zeal, his ambition, or his devotion to his profession, and especially to the reputation of the corps of which he was so bright an ornament.

"Of a sensitive, highly strung, nervous organization, the confinement, anxiety, and labor to which he was subjected in his attendance upon the late President Garfield during his long illness proved too much for a mind and body already overstrained by incessent labor and precipitated the illness which finally terminated his life.

"At the time of his death Dr. Woodward was a member and ex-President of the American Medical Association, a member and ex-President of the Washington Philosophical Society, a member of the National Academy of Science, of the Association for the Advancement of Science, of the Academy of Natural Sciences of Philadelphia, and of the College of Physicians and Surgeons of Philadelphia. He was an honorary member of several American and foreign scientific, medical, and microscopical societies, and the recipient of many distinguished honors from learned bodies in this country and abroad."

LIST OF THE PUBLICATIONS OF DR. J. J. WOODWARD, U. S. ARMY.

ARRANGED IN ORDER OF DATE.

1858.

Report of cases treated at the Surgical Clinic of the University of Pennsylvania. Am. J. M. Sc., Phila., 1858, n. s. xxxv, 344.

Remarks upon the minute anatomy of three cases of cystocarcinoma. Am J. M. Sc., Phila., 1858, n. s. xxxvi, 54.

1859

Remarks on the anatomical diagnosis of cancer. Am. J. M. Sc., Phila., 1859, n. s., xxxvii, 67.

Contributions to the literature of carcinoma. 1. On transition forms between cancer and innocent growths. 2. Anatomy of a case of retrograde cancer. Am. J. M. Sc., Phila., 1859, n. s., xxxvii, 297.

Contributions to pathological histology. 1. On suppuration in cancerous growths. 2. Remarks on the anatomy of five cases of non-cancerous new formations of connective tissue. Am. J. M. Sc., Phila., 1859, n. s., xxxviii, 309.

Pathology and treatment of tuberculosis. Abstract of discussion of, before Phila. County M. Soc., October 12, 1859. Phila. M. and S. Reporter, Phila., 1859-60, iii, 159.

1860.

Contributions to pathological histology. 1. Remarks on errors in the anatomical diagnosis of cancer. 2. Remarks on a secondary cancer of the axilla. Am. J. M. Sc., Phila., 1860, n. s., xxxix, 331.

Seven cases of telangiectasis or vascular tumors. M. and S. Reporter, Phila., 1860, v, 307.

Four cases of cancer. M. and S. Reporter, Phila., 1860, v, 336.

Heart clot. Report of committee to Phila. County M. Soc. M. and S. Reporter, Phila., 1860-1, v, 399.

1863.

Report on the sickness and mortality in the U. S. Army for the year ending June 30, 1862. Am. M. Times, Phila., 1863, n. s., vi, p. 166.

Hospital gangrene (letter to Prof. Detmold). Am. M. Times, 1863, vi, 179.

The hospital steward's manual, etc. Phila., J. B. Lippincott & Co., 1863.

Outlines of the chief camp diseases of the United States armies, as observed during the present war. Phila., J. B. Lippincott & Co., 1863, xii, 364, 8vo;

also [Rev.] Am. J. M. Sc., Phila., 1864, n. s., xlviii, 159, and Am. M. T., Phila., 1864, viii, 33–47.

Circular No. 15, War Department, Surgeon General's Office. 8 pp., 8vo. Washington, September 8, 1863. Sickness and mortality of the army during the first year of the war, with six diagrams.

1865.

On the use of aniline in histological researches, with a method of investigating the histology of the human intestine, and remarks on some of the points to be observed in the study of the diseased intestine in camp fever and diarrhœa. Am. J. M. Sc., Phila., 1865, n. s., xlix, 106.

Circular No. 6 [with Dr. G. A. Otis, U. S. army]. War Department, Surgeon General's Office. 164 pp., 4to. Washington, November 1, 1865. Reports on the extent and nature of the materials available for the preparation of a medical and surgical history of the rebellion.

1866.

Report on the causes and pathology of pyæmia (septicæmia). Tr. Am. M. Ass., Phila., 1866, xvii, p. 171.

On photo-micrography with the highest powers, as practiced in the Army Medical Museum. Am. J. Sc., and Arts, N. Haven, 1866, n. s., xlii, 189.

On microphotography with high powers. Quart. J. Micr. Sc., Lond., 1866, vi, 165.

1867.

Circular No. 5. War Department, Surgeon General's Office. xviii, 65 pp., 4to. Washington, May 4, 1867. Report on epidemic cholera in the army of the United States during the year 1866.

Catalogue of the medical section of the United States Army Medical Museum. 136 pp., 4to. Gov. Print. Office, 1867.

On monochromatic illumination. Quart. J. Micr. Sc., London, 1867, vii, 253.

1868.

Circular No. 1. War Department, Surgeon General's Office. 156 pp., 4to. Washington, June 10, 1868. Report on epidemic cholera and yellow fever in the army of the United States during the year 1867.

Remarks on the new nineteen-band test plate of Nobert. Quart. J. Micr. Sc., Lond., 1868, n. s., viii, 225.

Remarks on the nineteen-band test plate of Nobert. Am. J. Sc. and Arts, N. Haven, 1868, 2 s., xlvi, 352.

1869.

On the permanent preservation of histological preparations, as practiced at the Army Medical Museum, Washington, D. C. Am. J. M. Sc., Phila., 1869, n. s., lvii, 277.

Heliostat for photomicrography. Month. Micr. J., Lond., 1869, i, 29.

Abstract of lecture on photo-micrography applied to class demonstrations.

Dental Cosmos. Phila., 1869, xi, 397; repub. in Month. Micr. J., Lond., 1869, ii, 165.

Further remarks on the new nineteen-band test plate of Nobert and on immersion lenses. Month. Micr. J., Lond., 1869, ii, 289. [See notes in vol. iii, 1870, pp. 50 and 103, with regard to omission of diagram belonging to this article.]

Additional remarks on the nineteen-band test plate of Nobert. Am. J. Sc. and Arts, N. Haven, 1869, 2 s., xlviii, 169.

1870.

The Medical and Surgical History of the War of the Rebellion. Part I, vol. I, medical history, Washington, Gov. Print. Office, 1870, 4to, 726 pp.

Report of the committee on medical literature. Tr. Am. M. Ass., Phila., 1870, xxi, 107.

Report on the magnesium and electric lights, as applied to photo-micrography. Surgeon General's Office, January 5, 1870, 4to., 6 pp., 11 photographs; *also* reprint, Month. Micr. J., Lond., 1870, iii, 290; *also* Am. J. Sc. and Arts, N. Haven, 1870, 2 s., xlix, 294; *also* Brit. J. Photog., Lond., 1870, xvii, 270–282; *also* J. Franklin Inst., Phila., 1870, lix, 267.

Letter to Mr. Jabez Hogg with regard to Dr. Pigott's papers on the markings of certain test objects, particularly the Podura scale. Month. Micr. J., Lond., 1870, iii, 324.

Report on the oxy-calcium light as applied to photo-micrography. 4to., 3 pp., 2 photographs. Surgeon General's Office, 1870; *also* Reprint Am. J. Sc. and Arts, N. Haven, 1870, 2 s., l., 366; *also* Month. Micr. J., Lond. 1870, iv, 64.

The definition of Nobert's lines. Month. Micr. J., Lond., 1870, iv, 113.

Report on certain points connected with the histology of minute blood-vessels. 4to., 8 pp., 11 photographs. Surgeon General's Office, 1870, July 6th; *also* Reprint Month. Micr. J., Lond., 1870, iv, 205; *also* Quart. J. Micr. Sc., Lond., 1870, x, 380; *also* N. Y. M. Record, 1870–71, v, 313.

1871.

Memorandum on the amphipleura pellucida. 4to., 1 p., 2 photographs. Surgeon General's Office, 1871, Feb'y 1; *also* Reprint Am. J. Sc. and Arts, N. Haven, 1871, i, 345; *also* Month. Micr. J., London, 1871, vi, 43.

Memorandum on the surirella gemma. 4to., 1 p., 2 photographs. Surgeon General's Office, 1871, Feb'y 1; *also* Reprint Am. J. Sc. and Arts, N. Haven, 1871, i, 347; *also* Month. Micr. J., Lond., 1871, vi, 100.

On the structure of the podura scale and certain other test objects, and of their representation by photo-micrography. Month. Micr. J., London, 1871, v, 149.

Additional observations concerning the podura scale. Month. Micr. J., Lond., 1871, v, 245.

Memorandum on the test podura. 4to., 3 pp., 5 photographs. Surgeon General's Office, Feb'y 22, 1871.

On the use of the Noberts plate. Month. Micr. J., London, 1871, vi, 26.

Memorandum on pleurosigma angulatum and pleurosigma formosum. 4to., 4 pp., 8 photos. Surgeon General's Office, June 9, 1871.

Report on the pathological anatomy and histology of the respiratory organs in the pleuro-pneumonia of cattle, with 6 lithographs from photomicrographs. 22 pp., 4to. Washington, 1870; *also* in Rep. Commissioner Agricul. on the diseases of cattle in the United States. Gov. Print. Office, 1871.

Report on an improved method of photographing histological preparations by sunlight. 10 pp., 4to., 11 photos. Surgeon General's Office, 1871; *also* reprint Am. J. Sc. and Arts, N. Haven, 1871, 3 s., ii, 258; *also* Month. Micr. J., Lond., 1871, vi, 169; *also* Brit. J. Photog., Lond., 1871, xviii, 507.

Remarks on a case of supposed hermaphroditism. Am. J. M. Sc., Phila., 1871, n. s., lxii, 123.

Note on the resolution of amphipleura pellucida by a Tolle's immersion $\frac{1}{5}$th. Month. Micr. J., Lond., 1871, vi, 150.

The note accompanying three photographs of degeeria domestica, as seen with Mr. Wenham's blackground illumination and a power of 1,000 diameters. Month. Micr. J., Lond., 1871, vi, 266.

Note on the angle of aperture of Tolle's immersion $\frac{1}{5}$th. Month. Micr. J., Lond., 1871, vi, 290.

The Army Medical Museum at Washington. Lippincott's Mag., March, 1871, 233.

1872.

Microscopical memoranda for the use of practitioners of medicine. Lens, Chicago, 1872, i, 34, 93, 158, 223.

On the double markings of triceratium. Lens, Chicago, 1872, i, 100; *also*, Abs. Month. Micr. J., London, 1872, viii, 32.

Four letters to the Surgeon General accompanying photographs of the mosquito, certain parasites, the proboscides of certain flies, and miscellaneous photographs of insects and parts of insects, 8 pp., 4to., 35 photos. Surgeon General's Office, 1872, Jan. 5, 10, 15, 20.

Report on the minute anatomy of two cases of cancer. 10 pp., 4to., 2 photo-lithographs; Surgeon General's office, 1872, April 29; *also* reprint Month. Micr. J., Lond., 1872, viii, 109.

Note on Dr. Barnard's remarks on "the examination of Nobert's nineteenth band." Month. Micr. J., Lond., 1872, vii, 10.

Reply to Mr. Stodder, "B," and Mr. Edwin Bicknell. Letter to editor. Month. Micr. J., Lond., 1872, vii, 27.

Note on the resolution of amphipleura pellucida by certain objectives made by R. and J. Beck and by William Wales. Month. Micr. J., Lond., 1872, vii, 165.

On the use of monochromatic sunlight as an aid to high power definition. Am. Naturalist, Salem, 1872, vi, 454; *also* reprint Month. Micr. J., Lond., 1872, viii, 186.

Remarks on the desirability of reproducing photographs of scientific objects, and especially of magnified microscopical preparations in a permanent

form by some photo-mechanical method. Abst. Bull. Phil. Soc., Wash., 1871–'4, i, 41.

The use of amphipleura pellucida as a test object for high powers. Am. Naturalist, Salem, 1872, vi, 193.

Remarks on the Woodbury photo-relief process. Abst. Bull. Phil. Soc., Washington, 1871–'4, i, 57.

Remarks on the nomenclature of achromatic objectives for the compound microscope. Am. J. Sc. and Arts, N. Haven, 1872, 3 s., iii, 406; *also* reprint Month. Micr. J., Lond., 1872, viii, 66; *also* Am. J. Micr., N. Y., 1881, vi, 77.

Memorandum on the nineteen band test-plate of Nobert, 4 pp., 4to., 9 photos. Surgeon General's Office, 1872, Sept. 29.

Reply to further remarks on Tolle's $\frac{1}{5}$th and Powell and Lealand's immersion $\frac{1}{16}$th. Month. Micr. J., Lond., 1872, viii, 158.

Remarks on the resolution of the nineteenth band of Nobert's plate by certain objectives, especially by a new Tolle's immersion $\frac{1}{18}$th. Month. Micr. J., Lond., 1872, viii, 227.

In reply to Dr. Lionel S. Beale. Lens, Chicago, 1872, i, 208.

Note on the frustulia saxonica as a test of high power definition. Lens, Chicago, 1872, i, 233.

Report as to the classification of diseases which should be adopted for the 9th census. Rep. Ninth Census, 1872, ii, 5, Washington, Gov. Print. Office.

1873.

Remarks on the aperture of object-glasses. Month. Micr. J., Lond., 1873, ix, 268; *also* reprint, Lens, Chicago, 1873, ii, 145.

Nobert's tests and Mr. Webb. Letter to the members of the Quekett Microscopical Club. J. Quekett Micr. Club, Lond., 1872–'4, iii, 198; *also* reprint, Lens, Chicago, 1873, ii, 222.

On immersion objectives of greater aptitude than corresponds to the maximum possible for dry objectives. Month. Micr. J., Lond., 1873, x, 210.

On Webb's test and other fine writing on glass. Lens, Chicago, 1873, ii, 225.

On the structure of cancerous tumors and the mode in which adjacent parts are invaded [1st Toner Lecture]. Smithsonian Miscellaneous Collections, No. 266, 1873, 35 pp., 4to, 74 photo-micrographs; published by the Smithsonian Institution, Wash., 1873; *also* [rev.] Edinb. M. J., 1874, xx, 444; *also* Phila. M. Times, 1873–'4, iv, 301; *also* Atlanta M. and S. J., 1873–'4, xi, 660; *also* Am. J. M. Sc., Phila., 1874, n. s., lxviii, 219.

1874.

On some photographs of microscopic writing. Letter to Mr. John E. Ingpen, F. R. M. S. J. Quekett Micr. Club, Lond., 1872–'4, iii, 228.

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MEMOIR

OF

ARNOLD GUYOT.

1807-1884.

BY

JAMES D. DANA.

READ BEFORE THE NATIONAL ACADEMY, APRIL 21, 1886.

BIOGRAPHICAL MEMOIR OF ARNOLD GUYOT.

It is a remarkable fact in the history of American science that, forty years since, the small Republic of Switzerland lost, and America gained, three scientists who became leading men of the country in their several departments—AGASSIZ, in Zoölogy, GUYOT, in Physical Geography, and LESQUEREUX in Paleontological Botany; Agassiz coming in 1846, Guyot and Lesquereux in 1848. A fourth, Mr. L. F. DE POURTALÈS, who accompanied Agassiz, also merits prominent mention; for he was "the pioneer of deep-sea dredging in America."* The Society of the Natural Sciences at Neuchâtel lost all four. As an American Academy of Sciences we cannot but rejoice in our gain; but we may also indulge at least in a passing regret for Neuchâtel, and recognize that in the life and death of Agassiz, Pourtalès, and Guyot we have common interests and sympathies.

My own acquaintance with Prof. Guyot commenced after his arrival in America, when half of his life was already passed. In preparing this sketch of our late colleague, I have therefore drawn largely from others, and chiefly from his family, and from a memorial address by Mr. Charles Faure, of Geneva, one of his pupils, which was published in 1884 by the Geographical Society of Geneva.†

Youth. Education in Switzerland and Germany, 1807 *to* 1835.—To obtain a clear insight into the character of Prof. Guyot, it is important to have in view, at the outset, the fact that the Guyot family, early in the sixteenth century, became protestants, through the preaching of the French reformer, Farel, the cotemporary of Luther; and also, the sequel to this fact, that at the revocation of the edict of Nantes, the Guyot family was one of the sixty that moved into the principality of Neuchâtel and Valangin from the valleys of Pragela and Queyraz in the high Alps of Dauphiny. Thus the race was one of earnestness and high purpose, of the kind

* A. Agassiz, Amer. Jour. Sci., 3d Ser., xx, 254, 1880.

† Vie et Travaux d'Arnold Guyot, 1807–1884, par Charles Faure, 72 pp. 8vo. Read before the Geographical Society of Geneva, April 25 and August 25, 1884.

and origin that contributed largely to the foundations of the American Republic.

Prof. Guyot's father, David Pierre, esteemed for his "prompt intelligence and perfect integrity," married, in 1796, Mademoiselle Constance Favarger, of Neuchâtel, "a lady of great personal beauty and rare nobility of character." Arnold Henri, one of twelve children, was born at Boudevilliers, on the 28th of September, 1807, and was named after the Swiss patriot of the fourteenth century, Arnold von Winkelried. About 1818 the family moved to Hauterive, three miles from Neuchâtel, where his father died the following year. From the house at Hauterive young Guyot had before him, to the southeastward, the whole chain of the Alps, from Mt. Blanc to Titlis; and his sensitive nature must have drawn inspiration from the glorious view—the same deep draughts that he attributed to young Agassiz, in his academic memoir of his friend, with reference to the same circumstance—the snowy Bernese Oberland, the Jungfrau, the Schreckhorn, the Finsteraarhorn, the Eigers, and other summits to Mt. Blanc, "looming up before his eyes in the view from his house." Such views are calculated to make physical geographers and geologists of active minds. Guyot early found pleasure in the collection of insects and plants, and evinced in this and other ways the impress that nature was making upon him.

Previous to the year 1818 and for a while after, Guyot was at school at La Chaux-de-Fonds, a noted village "at the foot of a narrow and savage gorge of the Jura," 3,070 feet above the sea. In 1821, then fourteen years of age, he entered the College of Neuchâtel, where he was a classmate of Leo Lesquereux, the botanist. "Guyot and I," says Lesquereux, "were, for some years, brothers in study, working in common, and often spending our vacations together, either at Guyot's home, at Hauterive, or with my parents at Fleurier; and I owe much in life to the good influences of this friendship." His studies were classical—Latin, Greek, and Philosophy—arranged for preparing a boy for the profession of the Law, Medicine, or Theology, with almost nothing to foster his love of nature.

In 1825, then eighteen, he left home to complete his education in Germany. After spending three months at Metzingen, near Stuttgart, in the study of the German language, he went to Carlsruhe where he became an inmate of the family of Mr. Braun, a man of

wealth and scientific tastes, the father of the distinguished botanist and philosopher, Alexander Braun, the discoverer of phyllotaxis—terms of intimacy with the family on the part of several of his relatives having been of long standing. The family comprised also a younger son and two daughters. Agassiz was then a student at Heidelberg, along with young Alexander Braun and Carl Schimper, but he spent his summer vacations at the Carlsruhe mansion. A vacation soon came. "The arrival of the eldest son of the house," says Guyot, "already distinguished by his scientific publications, with his three university friends—Agassiz, Schimper, the gifted colaborer of Braun in the discovery of phyllotaxis, and Imhoff, of Bâle, the future author of one of the best Entomological Faunas of Switzerland and Southern Germany—was a stirring event, which threw new life into the quiet circle. After a short time devoted to a mutual acquaintance, every one began to work. The acquisition of knowledge was the rule of the day, and social enjoyment the sweet condiment to more solid food." "My remembrance," remarks Guyot, "of those few months of alternate work and play, attended by so much real progress, are among the most delightful of my younger days." "Add to these attractions the charm of the society of a few select and intimate friends, professors, clergymen, and artists, dropping in almost every evening, and you will easily understand how congenial, how fostering to all noble impulses, must have been the atmosphere of this family for the young and happy guests assembled under its hospitable roof." "Months were thus spent in constant and immediate intercourse with nature, the subjects of investigation changing with the advancing season. Botany and entomology had their turn," and "demonstrations of phyllotaxis," he says, "now reduced to definite formula by Braun and Schimper, and shown in various plant forms, but especially in pine-cones, were of absorbing interest. The whole plan of the present animal kingdom in its relations to the extinct paleontological forms was the theme of animated discussions." He adds, "It would be idle to attempt to determine the measure of mutual benefit derived by these young students of nature from their meeting under such favorable circumstances. It certainly was great, and we need no other proof of the strong impulse they all received from it than the new ardor with which each pursued and subsequently performed his life-work."*

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* Guyot's Academic Memoir of Agassiz, pp. 9–12.

Guyot took in, equally with Agassiz, the newly-developed views in botany, embryology, and zoological classification that were the subjects of thought and discussion, and became profoundly impressed thereby, as his later work shows.

From Carlsruhe, Guyot went to Stuttgart and took the course at the gymnasium, where he made himself a proficient in the German language. Returning to Neuchâtel in 1827, and there quickened in his religious faith and feelings by the preaching of the Rev. Samuel Petit-pierre, his benevolent impulses under a sense of duty led him to turn from science to theology, and commence serious preparation for the ministry. In 1829, then 22 years of age, having this purpose still in view, he went to Berlin to attend the lectures of Schleiermacher, Neander, and Hengstenberg, and there remained for five years—1830 to 1835. In order to meet his expenses he accepted the invitation of Herr Müller, Privy Counsellor to the King of Prussia, to live with him and give his children the benefit of conversation in French. The position brought him into intercourse with the highest of Berlin society, and was in many ways of great benefit to him.

While pursuing theology in earnest, his hours of recreation found him making collections of the plants and shells of the country, and otherwise following his scientific leadings. Humboldt introduced him to the Berlin Botanical Garden, where the plants of the tropics were a source of special gratification and profit. Moreover, other courses of lectures attracted him, as those of Hegel, of Steffens on psychology and the philosophy of nature, Mitscherlich on chemistry, Hofmann on geology, Dove on physics and meteorology, and especially those of Carl Ritter, the eminent geographer, whose philosophical views were full of delight to his eager mind and touched a sympathetic cord. Under such influence he found his love for nature-science rapidly gaining possession of him; and, yielding finally to his mental demands and to his conscience, which would not permit him to enter the ministry with a divided purpose, he determined to drop theology and make science his chief pursuit.

Ritter, of all his Berlin teachers, made the profoundest impression on his course of thought; and his biographical sketch of him, presented to the American Geographical Society in 1860, four years after his death, exhibits the admiring affection of a pupil who was like Ritter in his profounder sentiments. A paragraph from the memoir will show the tenor of Ritter's geographical teaching and

something of the mental affiliation between them. Guyot says (p. 48):

"Ritter, in the introduction to the 'Erdkunde,' declares that the fundamental idea which underlies all his work, and furnishes him a new principle for arranging the well-digested materials of the science of the globe, has its deep root in the domain of faith. This idea, he adds, was derived from an inward intuition, which gradually grew out of his life in nature and among men. It could not be, beforehand, sharply defined and limited, but would become fully manifested in the completion of the edifice itself. That noble edifice is now before us, and, unfinished though it be, it reveals the plan of the whole and allows us clearly to perceive that fundamental idea on which it rests. It is a strong faith that our globe, like the totality of creation, is a great organism, the work of an all-wise Divine Intelligence, an admirable structure, all the parts of which are purposely shaped and arranged and mutually dependent, and, like organs, fulfill, by the will of the Maker, specific functions which combine themselves into a common life. But for Ritter that organism of the globe comprises not nature only; it includes man, and, with man, the moral and intellectual life." "None before him perceived so clearly the hidden but strong ties which mutually bind man to nature—those close and fruitful relations between man and his dwelling place, between a continent and its inhabitants, between a country and the people which hold it as its share of the continent—those influences which stamp the races and nations each with a character of their own, never to be effaced during the long period of their existence." We have here ideas that took, in Guyot, a still larger expansion.

Guyot derived great profit also from the works and the friendship of Humboldt. His address at the Humboldt Commemoration of the American Geographical Society, in 1859, was a beautiful tribute to this model student of nature.*

The five years of study at the Berlin University terminated with an examination which brought him the degree of Doctor of Philosophy. His graduating thesis, written in Latin, as was then the rule, was on "The Natural Classification of Lakes."

To Paris, the Pyreness, Italy, etc., 1835 *to* 1839.—From Berlin,

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*Journal of the American Geographical Society, vol. I, p. 242, October, 1859.

Guyot, in his 28th year—June of 1835—went to Paris to take charge of the education of the sons of Count de Pourtalès-Gorgier, and continued with the family four years. Letters of introduction from Humboldt led to much intercourse with Brongniart and other savants of the great city. For the summer he accompanied the family to Eaux Bonnes, in the Pyrenees. While there he made ascents of the higher peaks and took excursions in various directions—to the amphitheatre of Gavarnie, to the borders of Spain by the Pont d'Espagne and the pass beyond, to the valley of the Eaux Chaudes, etc.—in order to study the features and flora, and compare the mountains in these respects with the Alps. In the autumn he went with his pupils to Belgium, Holland, and the Rhine to study the characteristic features of these countries. The following year he visited Pisa, and there, besides enjoying the new scenes, made various barometrical measurements, determining the elevation of the Observatory at Florence and of other points.

Trip to the Glaciers in 1838.—In the spring of 1838 Agassiz found Guyot still at Paris. During the summer preceding Agassiz had startled the scientific world by his declarations as to a *Universal Glacial Era*, contained in a paper read before the Helvetic Society of Natural Sciences assembled at Neuchâtel. His work in 1837—prompted in 1836 by Charpentier's discoveries proving the fact of a former epoch of immense glaciers in Switzerland—had led him to the bold conclusion, and he was full of his new idea when he met his old companion. He urged Guyot, who hesitated at accepting his views without examination, to study the facts, and obtained the promise that he would visit the glaciers that summer.

In his memoir of Agassiz, Guyot states that his six weeks of investigation that season in the Central Alps (nearly two years before Agassiz commenced his investigations on the Glacier of the Aar) were fruitful beyond expectation. He says that, from the examination of the glaciers of the Aar, Rhone, Gries, Brenva, and others, he learned (1) the law of the moraines; (2) that of the more rapid flow of the center of the glacier than the sides; (3) that of the more rapid flow of the top than the bottom; (4) that of the laminated or ribboned structure ("blue bands"); and (5) that of the movement of the glacier by a gradual molecular displacement, instead of by a sliding of the ice-mass, as held by de Saussure.

The facts and conclusions were communicated to the Geological Society of France at a meeting at Porrentruy, in September, 1838.

The communication is mentioned in the Bulletin of the Society for that year,* but no report of it is given because the manuscript remained in his hands unfinished, in consequence of his protracted illness the winter following. The portion then finished (which was withheld from publication because, by special arrangement between them, Agassiz in 1840 entered upon the special study of the glaciers and Guyot on that of the Swiss erratic phenomena, for their separate parts of a general survey) has recently been printed in Volume XIII (1883) of the Bulletin of the Neuchâtel Society of Natural Sciences. In 1842 this manuscript was deposited, by motion of Agassiz, in the archives of the Neuchâtel Society, and in 1848 it was withdrawn by Guyot when he left for America. It is to be regretted that publication was not substituted in 1842 for burial. Its recent publication was made by the request of Guyot, early in 1883, from a certified copy of the original manuscript.

This paper gives the facts on which Guyot based his conclusions, and since these conclusions comprise some of the most important of the views now accepted relating to glacier motion and structure, and antedate the observations of Agassiz, Rendu, and Forbes, they have special interest.

The fact of *a less rapid movement of the bottom ice than the top, owing to friction,* he ascertained by the observation that in glaciers of steep descent, like the Rhone at its rapids, and the Gries, the transverse crevasses and the masses they cut off are at first vertical or nearly so; but below the rapids, where the slope is gentle and the crevasses become mostly closed, the masses are inclined with the pitch up stream, and this up-stream inclination is reduced at the termination of the glacier to a few degrees. The crevasses, although closing up below, are still traceable. He says the so-called layers are not strictly layers; but great numbers of cracks remain, which give to the mass the appearance of being made up of beds several yards thick, as may be seen in the glaciers of the Grindelwald valley, Aar, and others.

Further: To this pitch in the stratification at the lower extremity, the beds rising outward, Guyot attributes also the origin of the majestic ice-chambers, whence in most cases flow great streams, as that of the Rhone, of the Arveyron at the foot of the Mer de Glace, of the Lütschinen from the glaciers of Grindelwald.

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* Volume IX, page 407.

The *more rapid movement of the centre than the sides* also was learned from the Rhone glacier and others of steep descent. The crevasses, at first transverse, were found to be arched in front below the rapids, and increasingly arched to the extremity, and the successive crevasse-lines were very nearly concentric with the semicircular outline of the extremity of the glacier. He gives a figure of the Rhone glacier as seen from the Maienwand in illustration, and other later glacialists have appealed to the same evidence of lateral friction.

The semicircular outline of the terminal moraine was found to be another result of the cause just mentioned; and so also the "even-tail" arrangement of the several moraines immediately above the termination. The greater height and breadth of the central moraine is made a consequence of the greater velocity of the ice at the middle of the upper surface, more transportation taking place consequently in a given time.

Again: The conclusion that *the movement of the glacier was largely through molecular displacement* was supported by his observation that the ice, instead of breaking up and rising into an accumulation of masses on its passage by an isolated rock, or rocky islet, in its course, spread around and enveloped it without fracturing; and he refers to a fine example of this at the two isolated islets of rock in the midst of the great Brenva glacier, called the eyes of the glacier." The same thing is observed "at the Jardin du Talèfre, a true islet in the midst of a *mer de glace*, having a border of blocks of rock, or of a moraine, cast upon its sides by the march of the glacier, just like the coast dunes of an island in the ocean."

In view of such facts, Guyot observes: "If it is true that the different parts of a glacier move with different velocities; if the glacier adapts itself to the form of a valley and fills all depressions without ceasing to be continuous; if it can bend around an obstacle and closely enclose it without the fracturing of its mass, like a spreading liquid, we may affirm that the movements take place through a molecular displacement, and we must abandon, at least as the only cause, the idea of a slow sliding of the mass upon itself as incompatible with the phenomena presented.*

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* In French his words of 1838 are: "On peut affirmer que ces mouvements ne peuvent avoir lieu qu' en vertu d' un déplacement moléculaire, et il faut abandonner, au moins comme cause unique, l' idée d' un glissement lent de la masse sur elle même, comme incompatible avec les phénomènes que presente la marche des glaciers."

The "blue bands" of the glacier were first described by Guyot. He called the structure stratification, and observed it in the ice of the summit of the glacier of Gries, at a height of about 7,500 feet. A peculiar furrowing of the surface of the ice, the furrows one or two inches broad, attracted his attention; and this result of weathering he found to have come from the unequal firmness of the layers constituting it, layers of a softer "snowy ice" alternating with those of firm bluish glassy ice. The stratification was found by him to extend over hundreds of square meters, and downward, on the sides of crevasses, twenty to thirty feet deep, or as far down as the eye could penetrate; and it was evident that "the layers of the two sides of a crevasse were once continuous, like the strata of the opposite sides of a transverse valley." He compared the stratification to that of certain coarsely schistose limestones.*

He remarks, in conclusion: "We should say that the layers were not annual layers, but rather a series made day by day from small successive snow-falls that were melted in part by the sun of the day, and covered each night by the thick frost-glazing which envelops all the snowy summits of the high Alps."†

He further observes that "these beds were evidently formed at a greater height and in a different position from that where observed." He adds, in closing his remarks on the subject: "Do the beds, at first horizontal, or at least parallel to the surface of the glacier, accomplish, during its movement, evolutions, as yet imperfectly understood, analogous to those before mentioned [that is, those occasioned by differences in velocity of the middle, sides, and bottom, owing to unequal friction]. This is a point which should have further examination, with observations as minute, numerous and universal as possible. Unfortunately a thick fog and threatening weather forced me to stop work before I had ascertained whether this structure was general for the whole mass of the glacier at that altitude, or whether restricted to that locality notwithstanding the proof of so large an extension of it."

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*His words are: "Stratifié à la façon de certains calcaires grossièrement schisteux," and he explains it himself as implying a lamellar structure.

†In the original, the words are: "On aurait dit, non pas des couches annuelles, mais une série de couches plutôt journalières de neige tombée successivement par petites quantités, puis fondue en partie par le soleil de la journée, et couverte chaque nuit de cet épais verglas qui, au dessus de la région des glaces, recouvre toutes les sommités neigeuses des hautes Alpes."

Guyot had some confidence in his conclusions, but he also felt, as he states, the importance of more detailed investigation in order to decide on their real value.

On the 1st of December, 1841, Guyot communicated the results of his observations of 1838, so far as relates to the "blue bands," at a meeting of the Neuchâtel Society of Natural Sciences, "reading some passages from his note written in 1838." This communication contains the additional fact that the layers of the stratification in the Gries glacier were inclined about 45°, were nearly transverse to the principal glazier, and appeared also to have sinuosities due to lateral compression.*

Agassiz, in his Système Glaciare (1847), cites from Guyot's manuscript (then deposited with the Neuchâtel Society) the part relating to the "blue bands" (the only part he ever cited), and in this citation there is a paragraph on the inclination or pitch of the layers, with Guyot's additional suggestion that the pitch of the layers looked as if a result of the advance of the surface portion over that below, a point already explained by him [by reference to friction at bottom].†

Guyot opens his account of the blue bands with the remark that, as he had seen them only on one occasion, he dares not hazard an explanation; but his later sentences show that he was inclined to regard them as a result of deposition, and to consider the varying inclinations in the layers as due to subsequent disturbing action—that is, to the irregularities of glacier movement, caused by friction and pressure under the varying conditions of the glacier valley as to form and size.

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* The report of the meeting of the Neuchâtel Society is contained in the Verhandlungen of the "Schweiz. Nat. Gesellschaft," Altdorf, 1842. The abstract of Guyot's communication there given (pp. 199–200) says: "La position de ces couches etait inclinée d'environ 45° dans le sens de la pente générale du glacier. Leur direction semblait presque transversale à celle du glacier principal, mais longitudinale à celle de son penchant méridional. Elle présentait quelquefois des sinuosités qui semblaient un effet de compression laterale."

† The cited paragraph in the Système Glaciaire (p. 209) is as follows: "La direction de ces couches coupait à angle droit la ligne de marche (de pente) du glacier, leur inclination déviait de 30° a 40° de la perpendiculaire vers la partie inférieure, comme si la pente superficielle gagnait de l'avance sur la partie inférieure ainsi que je l'ai décrit plus haut." The writer learns from Mrs. Arnold Guyot that this paragraph is a part of the original manuscript, and that it was by oversight that it was not sent to the Neuchâtel Society in 1883 with the rest.

Whether right or wrong in these suggestions as to the bands, Guyot's six weeks' work in the summer of 1838 was indeed fruitful. He had the satisfaction of seeing his conclusions for the most part confirmed by the facts collected by Agassiz, Forbes, and others, but not of receiving credit for his work and original conclusions, except on one point, and chiefly because of the want of proper publication.*

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* Rendu's "Théorie des Glaciers de la Savoie" was published in 1841 (Mem. Soc. Roy. Savoie, Chambéry, vol. X). Forbes's first letter from the Alps, announcing his discovery in August, 1841, of the "blue bands" in the Aar Glacier, was communicated to the Royal Society of Edinburgh December 6, 1841, and published in January in Jameson's N. Phil. J., vol. XXXII, 1842. Agassiz's first work on glaciers, "Etudes sur les Glaciers," was published in 1840. Neither of these publications mentions Guyot or his observations.

Guyot's communication of 1841, published in the Altdorf Verhandlungen, was drawn out by a discussion between Forbes and Agassiz relating to priority as to observations on the blue bands, and it was made just five days before Forbes's first letter was read in Edinburgh. Agassiz claimed credit for Guyot at the meeting in 1841, as a set-off against Forbes's claim, and again, in the N. Phil. Journ., XXXIII, 265, 1842. Forbes, in the following volume of that journal, XXXIV, 145, 1843, gives Guyot credit for original discovery as regards the "blue bands," and speaks of his corresponding with him on the subject; and he repeats the acknowledgment to the "ingenious professor of Neuchâtel," in his Travels through the Alps of Savoy, 1843 (first edition) and 1845 (second edition), page 28. Desor, in the same journal, XXXV, 308, 1843, in a paper on Agassiz's recent glacier researches, introduces a translation of Guyot's account of the banded structure, but cuts it short at the words "opposite sides of a transverse valley," leaving off the explanatory remarks which follow.

Tyndall, in his "Forms of Water" (1872, page 183), gives Guyot credit for priority; and he cites, both in this work and in his earlier "Glaciers of the Alps" (1856), a translation of Guyot's account, ending it a sentence short of Desor's citation, with the words "certain calcareous slates" in place of Guyot's "certain schistose limestones;" and on page 187 of "The Forms of Water," knowing only a part of what Guyot had written, he does him more than justice (admitting Tyndall's view to be established) in saying that he "threw out an exceedingly sagacious hint when he compared the veined structure to the cleavage of slate rocks," for the comparison in Guyot's paper implies rather stratification from deposition.

The first detailed comparison of the "blue bands" to slaty cleavage in structure, position, and origin appears to have been made by Prof. Henry D. Rogers at the Cambridge meeting of the American Association in 1849 (Proc. Am. Assoc., II, 181). But Rogers attributed the structure in both to conditions of temperature and not, like Tyndall, to pressure.

Having attended at Berlin the lectures of Dove on physics and meteorology and those of Ritter on physical geography, Guyot knew when he went to the mountains what to look for in case the glaciers were great flowing streams of ice, as had often been supposed; he knew that the flow of a stream is retarded along the sides and bottom by friction, and he naturally looked also for something in the encounter of the glacier with rocks answering to molecular displacement. Hence, in his six weeks of observations on the glaciers, he reached, without waste of time, good conclusions—the conclusions of a physical geographer. His investigation did not enable him to appreciate the interior fracturing that works along with molecular displacement in the flow of the ice, but his conclusion was still far in the right direction and decisive against the hypothesis he opposed. That he did not continue his study of the glaciers to thoroughly established results was owing to his yielding the subject afterward to Agassiz. Fidelity to his friend and his volunteered agreement curbed in and silenced him; and so his paper, excepting the paragraphs on the "blue bands," remained buried until after Agassiz's decease.

At Neufchâtel, Professor in the Academy, 1839 *to* 1848.—In 1839, at the age of thirty-two, Guyot left Paris and returned to his native town. He became at once an active member of the Society of the Natural Sciences (which had been initiated by Agassiz in 1832), and was made by the Society one of a committee—including also M. d' Osterwald and H. Ladame—for the organization of a system of meteorological observations in Switzerland and the selection of the best instruments for the purpose. On the establishment of the "Academy" at Neuchâtel, for the purpose of furnishing a university education to the graduates of the college or gymnasium, he was appointed to the chair of History and Physical Geography, and became a colleague of Agassiz. He hesitated about taking charge of the department of History, as this had not been one of his special lines of study; yet, once committed to it, he plunged into the subject with great earnestness. He says he groped on among the details for two years before he began to distinguish its grand periods, and the light as it broke in upon him caused so intense excitement that he was made ill.

Instruction was a great pleasure to him, because of his deep interest both in his subject and in his pupils. His two departments called out from him thirteen general and special courses of lectures.

With regard to the lectures, Mr. Faure says: "From the first, in spite of his apprehensions, he captivated his audience by his easy, elegant, sympathetic words, by the breadth of his views, and the abundance and happy arrangement of his facts. He had, each winter afterward, the pleasure of seeing men of cultivation of all classes in Neuchâtel pressing into the large hall of the college and listening to him with riveted attention." His pupil adds: "What zeal he inspired! what ardor for work! The fire with which he was filled passed to us. He was more than a professor; he was a devoted friend, a wise counsellor, associating himself with us and encouraging us in our work."

Guyot, besides lecturing and instructing, did all he could of outside work—meteorological, barometric, hydrographic, orographic, and glacialistic. The hydrographic work was the careful sounding of Lake Neuchâtel (in all 1,100 soundings) as the commencement of a study of the annual variation in the temperature of the waters of the Swiss lakes. His chief research—that on the distribution of the bowlders or erratics over Switzerland—occupied him, "single-handed, seven laborious summers, from 1840 to 1847," he allowing himself only, "at the end of his working season, the pleasure of a visit of a few days to the lively band of friends established on the Glacier of the Aar, in order to learn the results of their doings and communicate his own to them."* Switzerland in the ice period was his subject; and the sources of the bowlders and the courses of ice transportation were the chief inquiries. The investigation involved excursions on foot and careful examination of the whole range of the Swiss Alps, the slopes into Italy, the plains of Switzerland, and the mountains on the northern and western borders, including the Juras—in all an area of 190 by 310 miles—in order to trace the erratics to their high sources among the snowy summits, examine the rocks of all peaks, ridges, and valleys for comparison with those of the erratics, measure the heights along the lines and limits of the erratics from plain to mountain peak, and note all glacial markings. The task was accomplished with the greatest possible fidelity; "thousands of barometric measurements" were made in the course of it, and between 5,000 and 6,000 specimens were gathered in duplicate.

Thus, says Guyot:

"Eight erratic basins were recognized on the northern slope of the

*Memoir of Agassiz, page 39.

Alps—those of the Isère, the Arve, Rhone, Aar, Reuss, Limmat, Sentis, and Rhine; and four on the southern slope—that of the Adda, including Lake Como, of Lugano, of Ticino, including L. Maggiore, and that of the Val d'Aosta."

Moreover, a question left hitherto untouched—the distribution in each basin of the rocks special to it—was minutely examined, and the final results of all the laws observed in the arrangement of the erratic fragments were shown to be identical with the laws of the moraines. This identity, and the absolute continuity of the erratic phenomena from the heart of the Alps down the valleys and beyond to the Jura left no alternative but to admit the ancient existence of mighty glaciers as vast as the erratic regions themselves, and having a thickness of over 2,000 feet."

Brief notes on his work were published in the Bulletin of the Neuchâtel Society of the Natural Sciences for November, 1843, May and December, 1845, and January, 1847.*

Guyot reserved the complete report for the second volume of Agassiz's great work on glaciers. But, unfortunately, after the first volume by Agassiz appeared at Paris, in 1847, there came the revolution of 1848, which put an end to their plans.

The study of the geological structure of the Jura mountains, in which he worked out the system in the flexures of the strata and proved that it must have been produced by lateral pressure, was another of Guyot's labors soon after his return to Neuchâtel, although not reported on until 1849, at the Cambridge meeting of the American Association.†

Guyot had been teaching at Neuchâtel nine years when suddenly the "Academy" was suppressed by the Grand Revolutionary Council of Geneva of 1848. The 13th of June brought the tidings, and on the 30th the end came "without any indemnity to the professors." Letters from Agassiz urged him to come to America. Though reluctant to take the step because of the many ties of friendship and association that bound him to Switzerland, and especially on account of the family under his charge, consisting of his mother, then seventy years old, and two sisters, which he should have to leave behind, he had the decision of his mother, after her careful reading of Agassiz's

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*The facts are well presented also, though briefly, in the second volume of D'Archiac's Histoire des Progrès de la Géologie, pp. 259–265.

† Proc. Amer. Assoc. II, 115, 1850.

letter, in favor of it,* and in the following August he left friends, home, and Europe.

In America. The Lowell Lectures at Boston. "Earth and Man." 1848, 1849.—Without English speech, with no plans ahead, and with more than forty years of his life behind, a crowd of apprehensions continued to haunt Guyot until he reached the American shores. Once landed in New York, he was soon after at Cambridge with his friend Agassiz; and from that time the calamity that had befallen him commenced to prove itself a blessing. It was for him, falling in with the "geographical march of history," and coming to the land and "people of the future," where no political or religious shackles were in the way of success, and where an audience as wide as the continent was ready for whatever he had to communicate.

In September, a fortnight after his arrival, Agassiz took Guyot to the meeting of the American Association at Philadelphia. At its close he made his first journey to the Alleghanies, spending a week in crossing the region in Pennsylvania to Bedford and Cumberland. On his return he stopped in Princeton to deliver a letter of introduction to Dr. Charles Hodge, and found there friends who later welcomed him as a colleague.

Returning to Cambridge, he was soon afterward invited by Mr. Lowell to deliver one of the winter courses of lectures at the Lowell Institute, and in January he resumed in Boston his academic work, taking for his subject *Comparative Physical Geography.* He spoke in French, almost without notes, to a large and appreciative audience, and from that time the Swiss professor had an American reputation. These lectures, written out after the delivery of each, were translated by Prof. Felton "with rare kindness and a disinterestedness still more rare," says Guyot,† and published under the title—now familiar—of "Earth and Man."

The views of Ritter, which had put life and humanity into geography, are used by the author as the basis of still wider generaliza-

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* August 8th, 1848, the day of his departure from Neuchâtel, he writes: "Ma mère a été toujours si forte et si confiante qu' elle m'a soutenu jusqu' au dernier moment, mais son dernier sanglot, en me quittant, m'est allé au cœur: Oh! que Dieu me donne de la revoir et d'embellir ses derniers jours."

This desire was realized. In the autumn of 1849 he had the happiness of welcoming his mother, two sisters, and a niece to the new home which he had prepared for them in Cambridge.

† In the dedication of "Earth and Man" to Prof. Felton.

tions bearing on the earth and human history. Guyot first draws out in admirable style the distinctive physiographic features of the continents and seas, and then proceeds to consider the *physiology* of the continental forms, by which he meant the interactions of the continents in their own history, and in that of man as their tenant. Having finished the physiographic portraiture in the first seventy pages, he says: "We must now see these great organs in operation; we must see them in life, acting and reacting upon each other," that is, "their physiological phenomena."

In order to exhibit the "living" action between these "organs" in its true relations, he first explains the fundamental law of progress in all growth or development; then exhibits the application of the law to the earth in its genesis, and in its later progress through the ages, and finally draws out and puts into order the grander facts in the conditions of the earth connected with the development of man in his social, political and moral relations.

Guyot makes all historical progress a *development*, carried forward through the incessant action and reaction of differences or unlike conditions; he speaks of it as a gradual specialization of parts and functions, comparable to the progress in germ development and having the same general formula; as beginning in a homogeneous unit, which has real but unmarked differences of parts, advancing through various changes and individualizations, and ending in the complex "harmonic unit." He finds the law exemplified in the development of the earth after the nebular theory of La Place; in the slow progress of the earth's continents from the condition of scattered islands in a large shallow sea to that of united distinctively-featured lands; in the progress of the earth's life, as made known by geology; the progress in the development of the races of men, and in the origin of human societies. The three phases recognized in the process are that of undistinguishable parts, germ-like; that of diversification; that of unity, which "allows all differences, all individualities, to exist, but co-ordinates and subjects them to a superior aim." Further, the final product or "harmonic unit," be it an organic species, or a continent, or societies, or whatever condition, has its purpose fulfilled not in existing, but in preparing for and producing other development beyond.

As differentiation goes forward increasing differences, interactions become more energetic. The greater the variety of individualities and relations in a society of individuals the greater also is the sum

of life, the more universal, more complete, and more elevated the development.

Further, besides the unfolding of life "in all its richness of kinds and forms by diversity, there is involved an exhibition of it in its utility, in its beauty, in its goodness, by harmony; and this also for the entire globe, collectively considered as a single individual." This last point was the special subject of the larger part of his lectures.

Here was development for all history. All was put under one formula, that which is expressed in embryonic development, and was illustrated by details sustaining the application of the law.

With regard to the geological succession of life, he had learned, from Agassiz's announcements in his "Poissons Fossiles" (the first volume, published in 1834), that the geological succession in species was analogous in many respects to embryonic succession,* and he had gathered other ideas from the philosophical thoughts of Goethe and Steffens, as well as Ritter; but in his special application of the principle to the earth's early and latter history, and to human progress, he went beyond his teachers.

In reply to an inquiry as to the originality of his views, he wrote me, December 6, 1856, as follows:

"The principle at the basis of development is at the bottom of all the modern philosophy of Germany, especially the philosophy of nature, but in what an abstract and indigestible form will be seen on opening any one of their uninviting volumes. Goethe, the poet and philosopher, has, in a more concrete and tangible form, the beautiful law that the more homogeneous the lower the organism, and the more diversified in its parts the higher the grade. Steffens, of Berlin, acted more directly on my mind, and from him I got a distinct view of the importance of the internal contrasts and differences as regards the process of life." * * * "All these notions of the law were taken, as was natural, from the organized being; I do not recollect to have seen it applied, as I have applied it, to inorganic nature; to astronomy; to geology—I mean to the growth of continents, and to the successive and increasing diversifications of the surface keeping pace with the wants of an increasing development of life; to Physical Geography, in which the law of *in-*

* Quoted by Guyot in his sketch of Agassiz, page 26.

ternal contrasts, as conditions of a more active life, plays so great a part. Hence the whole scheme of that part of Earth and Man. This law thus became for me the key for the appreciation and understanding and grouping of an immense number of phenomena both in Nature and History. My views of the human races and of universal history are, in great part, on the same base. So also the idea of the true sense of the first chapter of Genesis as a characteristic of the great organic epochs."

His recognition of the same principle in organic nature is expressed as follows in a letter of March 17, 1856, referring in the first paragraph to the view of Agassiz that the subkingdoms among animals and the grander divisions among plants represent so many plans of structure:

"But do we not too much forget that even structure is but a means—the expression of a mode or function of life, which mode or function is the idea of it, and in one sense its cause? If so, then structures only express various aspects and functions of life, animal or vegetable, and they are related and connected together as the various aspects, modes, and functions of organic life are with the essential idea of life itself.

"Now, life is essentially (I mean phenomenally) growth, development, movement from phase to phase, from birth to death, and it seems to me that I can find no principle which gives me a more clear, natural, and connected idea of the innumerable types and forms of vegetables and animals than to consider them as typical of so many phases of life, whether of growth, or mode of life, or function of life."

Guyot endeavored to find the expression of the formula of development in the details of the systems of life, animal and vegetable, as exhibited in the progressive life of the globe as well as the existing species; and the preceding sentences in his letters were introductory to further explanations with regard to this system. His philosophical ideas were broad and deep enough to embrace the results of all discovery, although his illustrations manifested something of the limited knowledge of species and groups of thirty years since. In 1862 he delivered a course of lectures at the Smithsonian Institution on this subject, or "The Unity of Plan in the Systems of Life, as exhibited in the Characteristic Ideas and Mutual Relations of the great groups of the Vegetable and Animal Kingdoms;" but, although publication was desired by the Institution and urged by

others, the manuscript was never ready. Full stenographic reports were made, which he never found time to revise.

It is interesting to note, in both Agassiz and Guyot, this full faith in a system of development as the best and truest expression of the order of succession in the progress of life, and, in Guyot, the application of the principle to all progress, while, at the same time, neither doubted the constancy of species or the necessity of divine acts for originating species and carrying forward the development. Agassiz declares, in his "Poissons Fossiles:" "More than 1,500 species of fossil fishes with which I have become acquainted say to me that the species do not pass gradually from one to the other, but appear and disappear suddenly, without direct relations with their predecessors." To each the system of progress was as orderly a system as that which evolutionists now recognize. The successional relations made known by paleontology were welcomed for the same reason as now: because they illustrated the true system of progress. The difference was not as to these relations, or the system of progress, but as to the means of carrying forward the development.

Guyot also gives a brief explanation of his views with regard to the *Geographical March of Human History*, and this is all he ever published of his historical course. In the expression "geographical march" he refers to the fact that human progress took place not by gradual elevation at one centre of civilization, but by successive transfers from one nation or centre to another. He points out and illustrates three stages in the progress:

First. The stage characteristic of the old Orient—that of *subjection;* subjection not only to the despotism of rulers and of society through castes, but also to that of Nature's forces through fear and superstition, and to the despotism of priests, exerted over both people and rulers through the superstitious element, and to priests and rulers conjoined, making the subjection complete. It was "the subjection of human liberty to the yoke of nature," "to the immutable, blind laws of necessity, which regulate the courses of the celestial bodies and the life of nature;" to the "inflexible, unloving, inexorable gods of the early East."

Secondly. The stage of growth in *individual* freedom, worked out in, and characterizing, Greece—a land "neighboring still the East," but admirably organized by its very features, by the combination within it of all the contrasts of the continent, for the development of individuality; a free people full of the energy of youth and the

conscious strength of freemen, converting "the world of nature" into "that of the human soul," where "all the riches of poetry, of intellect, of reason, which are the heritage of the human mind, display themselves without obstacle and expand in the sun of liberty;" where "religion is a deification of the faculties and affections of man," where "the forces of nature, the trees of the forests, the mountains, the springs, and the rivers appear as objects of worship," "under the form of gods, of goddesses, and of nymphs, endowed with all the affections and subject to all the weaknesses of common mortals."

But, he says, the Empire of Alexander, and of individuality, and of fratricidal wars was not for the future. The Greek principle wanted the addition of association, "a principle determined by nature and not by voluntary agreement."

Third. The third stage was that of Rome, its centre a little farther toward the west, which through the spirit of *association* became the great empire and law-giver for the world. But selfish and corrupt, "one half of the men slaves to the other half," "exacting only one worship, that of the Emperor, who personifies the State," the Roman World, an aggregate of nations without a common faith, "perishes like the rest, of its own vices."

At that time, when the principle of association under human enactments was proving itself a failure, and despair was settling over the people, then, says Guyot, "the meek form of the Saviour appeared upon the scene of the world," to "recall man to the only living God," and "proclaim the equal worth of every human soul," "the unity and brotherhood of human kind." "It was upon this new basis that humanity, recommencing its task, goes on to build a new edifice." The task was not committed to the corrupt Roman; the Roman Empire broke before the Germans from the North, and the centre of civilization passed to the north of the Alps, and soon embraced all Europe. The new influences tended to harmonize the conflicting nationalties and bring about finally "a family of States so closely bound together that they are only members of the same body." And while liberty was thus gained for man, nature, as never before, opens herself to him and becomes his aid in all progress. Not only Europe, but, through her people, all the world receives the new light and commences to participate in the new progress.

But Europe and all the old nations, "through historical ties of every kind, ancient customs, acquired rights," encounter almost insurmountable difficulties in the way of adaptation to the exigencies

of a new principle—that of "liberty, equality, and fraternity" rightly interpreted; and the carrying out of this work to reality demanded for its full development, as the law of history shows, that it should be transferred "to a new people;" transferred, as "the geographical march of civilization tells us, to a new continent, west of the Old World—to America;" a land wonderfully adapted to this purpose by the simplicity and unity of its features, by its great plains and rivers, and by its commanding position between the oceans.

He says, in conclusion, referring to the historic nations: "Asia, Europe, and North America are the three grand stages of humanity in its march through the ages. Asia is the cradle where man passed his infancy under the authority of law, and where he learned his dependence upon a sovereign master. Europe is the school where his youth was trained; where he waxed in strength and knowledge, grew to manhood, and learned at once his liberty and his moral responsibility. America is the theatre of his activity during the period of manhood, the land where he applies and practices all he has learned, brings into action all the forces he has acquired, and where he is still to learn that the entire development of his being and of his own happiness are only possible by willing obedience to the laws of his Maker."

When Carl Ritter received a copy of the work "Earth and Man" from his old pupil, he sent Guyot a letter of congratulations, with the strongly underscored word, *excellent*, thrice repeated; and more than once he wrote him that the whole conception carried out in the volume was a marked progress. He also told Guyot that he had made the volume his *vade mecum* on a long summer journey.

The work has passed through several editions in Great Britain, and has been translated into German and Swedish; and a translation into French, by Mr. Faure, will be published this year in Paris.

Guyot's views put the earth's genesis or development, as a sentence cited from him shows, under his general formula for historical progress; and although the subject is not dwelt upon in his Earth and Man, a brief statement of his argument and conclusions is, therefore, in place here.

The subject came under his consideration at Neuchâtel, in 1840, while preparing a lecture for his course in Physical Geography. Looking only to the suggestions of science, under which the so-called

nebular theory had in his mind a place, he made out a scheme of the successive stages in the earth's development. After its completion it "flashed" upon him that the succession arrived at was just that of the cosmogonic record in Genesis, and this led later to a critical comparison of the two. Harmonizing the Bible and science was, hence, far from his original purpose.

The succession in the scheme so derived was (as I learned it from him) as follows:

First. The endowing of matter in space with forces, whence the beginning of its activity.

Second. The stage of specialization, or that of the subdividing of the original matter or nebula through the forces communicated, and thus the development of systems of spheres in space.

Third. The stage of the individualized worlds—the earth among them—and the commencing preparation of the earth for new developments pertaining to organic nature.

The events thus far are those of the inorganic part of the cosmogony.

In the organic period there was:

First. Life, manifested in the simpler kinds of plants. Next, animal or sentient life under simple forms—the Protozoans. These simple kinds of plants and animals represented the first or germ-like or homogeneous stage in the development of the system of life. He believed it to be probable that both existed before the close of Archæan time.

Second. The stage of specialization, or that of the development of plants and animals of higher and higher grade, under various types or subdivisions, based severally on different structural and physiological qualities.

Third. The stage of the synthetic or harmonic type. Among plants, that of the Dicotyledons, in which the different kinds of tissues in plants, and the stem, leaf, and flowers are for the first time harmoniously combined; and among animals, that of the Vertebrates, in which the nervous system has first its proper commanding position; and, lastly, among Mammals, that of Man, eminently the "harmonic unit" for the system of life, combining the highest of

structural qualities and physiological characteristics under the most perfect harmonious development.

It is not surprising that after the conception of such a scheme he should have recognized a relation in it to the record in Genesis. Looking to this record, which announces the grand stages in a few brief sentences, he observed that the "fiat" of the first day, "Let light be," indicated, since light is a result of molecular action, the imparting of activity to matter as the first step in the development of the universe; that the dividing of the waters on the second day appeared to have its only befitting explanation in the subdividing or specialization of the primal nebula, as stated above; and that the fiat "Let the dry land appear," on the third day, indicated the defining of the earth and the preparation of it by the appearance of dry land for its new work. Thus he found the first three works in Genesis to correspond essentially with the first three in the scheme taught him by science. The following works, the creation (*a*) of plants, (*b*) of the Invertebrates and inferior Vertebrates, (*c*) of Mammals—the remaining Vertebrates, (*d*) of Man, have in the record the order of their first appearance as made known by science. It has to be admitted that doubt at present exists as to the earliest birds having preceded the Marsupial Mammals, but none as to their long preceding ordinary Mammals. Future discovery may place them before the Marsupials. Remains of birds are the rarest of fossil Vertebrates.

Guyot recognized also a still deeper concordance between Genesis and science, namely, that not only in the opening verses, but throughout the chapter, the idea of a system of development is taught. The fiat "Let light be" was the commencement of developments before the earth or other spheres had existence, not the creation of an entity. With regard to the earth, the first verse announces that it was formless, empty, waste, or, as the Septuagint translation describes it, "uncomposed and invisible." Then, on the third day, where the second mention comes in, the words are not Let the earth be, but "Let the dry land appear," implying that the specializing changes had gone forward eventuating in the earth and making it ready for further developments. The fiat creating plants was not Let plants be, but "Let the earth bring forth," which words imply development in some way; and a similar idea is to be derived from the fiats "Let the waters bring forth" for the Invertebrates and lower

Vertebrates on the fifth day, and "Let the earth bring forth" for Mammals on the sixth day.

Such a system of developments, which, after an initiating fiat, continued on their progress through the ages following, was not consistent with the idea that the days of Genesis were definite periods of time. It teaches that they simply mark the beginnings of new phases or new grand stages in the history of creation.

Guyot's critical eye further discovered that the two triads of days in the record—the first, the *inorganic*, including days one to three, the second, the *organic*, days four to six—have three parallel features which emphasize strongly this subdivision of the chapter, and indicate parallel stages in the developments: first, in each triad, the work of the first day was light; second, in each, the work of the last day comprised two great works; third, the second work of the last day in each triad was the introduction of an element that was to have its full development in the following era; in the first triad this element was life, plants being the second work, and life having its chief display in the succeeding era; in the second triad it was spiritual life, that of man, a planting of the moral world in the material, for the exaltation of the latter in aim and character.

Guyot thus shows that the old document is philosophical in its arrangement, true to the principles of development in history, and essentially true in the order of its announcements, and that the best explanation which science is now able to give on the great subject of cosmogony is also that which best explains, in all its details, the first chapter of Genesis and does it justice.

I have said that Guyot, while adopting the law of development and applying it to all history, still believed that true species came into existence only by divine act. In his later years, as his work on "Creation" shows, he was led to accept, though with some reservation, the doctrine of evolution through natural causes. He excepted man, and also the first of animal life; for in the case of both, while science speaks undecidedly, the record in Genesis teaches, by the use of *bara* for create, and by not using the word elsewhere subsequent to the first verse in the chapter, that actual creation was intended. He also held that there might be other exceptions; and he objected, moreover, on other grounds to the development of Man through nature alone. Still, as always with Guyot, God's will was the working force of nature, and secondary causes simply expressions of it.

Guyot's views on Genesis, although dating from 1840, and pre-

sented by him since that time in occasional courses of lectures, were not published in detail until the last year and hours of his life. With the publication of the volume his work and life ended.*

Educational Work. 1849 *to* 1884.—I pass now to Guyot's work in America. His lectures at Boston were "a brief epitome of his teaching in Neuchâtel,"† and they were, therefore, a part of European Guyot. He now becomes, though European in equipment, an American in his labors.

His lectures had made him known as a Geographer of the widest and most elevated kind. From Agassiz's home at Cambridge his acquaintance extended rapidly, and he was soon known also as a man of practical ideas with regard to school instruction in Geography and in other subjects. It was at once accepted from him that the starting point in geographical education should be nature and not books; that teachers should take their pupils to the hills and show them the valleys and streams and mountains, and aid them in tracing out the general features, so that they might make themselves geographers of the region about them and lay a foundation for broader geographical study; that the study of the geography of nature should precede that of man and political geography; that maps showing in strong lines the reliefs, or the mountains and plains, and then those showing the river systems and other natural features, should come before those of States and towns. The idea commended itself that each country should be presented to the mind of the pupil by such groupings of prominent features, inanimate and animate, as would, so far as possible, reproduce the reality of nature; and that waters, lands, and climates should not merely be described, but also displayed in their mutual interactions and relations, and in their interactions with the living tribes of the waters and land, that thereby the activities of the earth and their varied consequences might be understood, and also the influences thence arising that bear on man and human history.

These views he had learned from his teacher, Carl Ritter, and the latter in part directly from Pestalozzi. They were so obviously good that they spread rapidly. Guyot was soon under appointment from

* Creation, or the Biblical Cosmogony in the light of Modern Science. 136 pp., 8vo., Scribner's Sons, New York, 1884. A short article by him appeared in 1873 in the report of the 6th conference of the Evangelical Alliance, New York.

† Letter to the writer of February 4, 1881.

the Massachusetts Board of Education, lecturing on geography and methods of instruction to the Normal Schools and Teachers' Institute; and this engagement took him to all parts of the State and gave him each year, for the six years he held the position, aggregate audiences of 1,500 to 1,800 teachers. His friend Agassiz, moreover, was associated with him in the work, giving a like and equally strong impulse to studies in Natural History.

Guyot lived to see his methods of instruction become universal. He furthered this end by preparing, on his plan, between the years 1861 and 1875, a series of school geographies of different grades, six in number, ending in a school physical geography, and also a series of wall maps, physical, political, and classical, thirty in number, all of which passed into wide use.* These books forced the old books and atlases to change about or succumb, and they led, also, to many imitations among book makers.

His plan for the completion of the series in a general Treatise on Physical Geography, unfortunately, was never carried out. His failure is to be attributed in part to the difficulty he felt in putting his ideas down in English. He writes in 1882 to his Swiss friend, M. F. Godet:† "Que ne donnerais-je pas pour avoir la facilité d'écrire et de dicter! Mais cette malheureuse langue, qui n'est pas la mienne, est un obstacle toujours renaissant. La phrase m' entrave et me coûte dix fois plus que les idées." That Guyot understood the language well is evident from his memoirs of Ritter and Agassiz, and his tribute to Humboldt, as well as from his scientific papers.

Besides the geographical works already mentioned, Guyot was the author of the Treatise on Physical Geography in Johnson's Family Atlas of the World, and editor, with President Barnard, of Johnson's New Universal Encyclopedia, in which are several papers by him on geographical and other subjects. His school atlases and geographies received the Medal of Progress at the Vienna Exposition in 1873, and the Gold Medal, the highest honor awarded, at Paris in 1878.

In 1854 Guyot received an appointment to the professorship of Physical Geography and Geology at Princeton, then established for

* Guyot had a valuable aid in map-making in his nephew, Mr. E. Sandoz, who came to America with him, after having previously spent two years at Gotha with the geographer and publisher, Herr Petermann.

† Mr. Faure's biographical sketch, page 39.

him on an endowment from one who had learned to admire him as a Christian philospher, Mr. Daniel Price of Newark, New Jersey,* and in 1855 he removed with his family from Cambridge to Princeton, where he found his tastes, his social instincts, his desires to impart ideas as well as acquire them, all fully gratified. To the duties of his professorship he permitted himself to add other educational work, becoming and continuing for several years Lecturer on Physical Geography in the State Normal School at Trenton, and from 1861 to 1866 Lecturer Extraordinary in the Princeton Theological Seminary, on the Connection of Revealed Religion and Physical and Ethnological Science, and also giving courses of lectures for a time in the Union Theological Seminary, New York, and in connection with a university course in Columbia College, New York. At the Smithsonian Institution he delivered a course of five lectures in 1853 on the Harmonies of Nature and History, and in 1862 six lectures on the Unity of Plan in the System of Life, as mentioned on page 20.

Besides class instruction at Princeton, Guyot did important work for the college in the establishment of a museum. He found nothing there of the kind; but by effort at home and while on a trip to Europe, and with the aid of students inspired by him, and the generosity of friends, the museum became, under his care, rich both paleontologically and enthnographically, and in foreign as well as American specimens. It derives special interest, moreover, from possessing, through his gift, the 5,000 rock specimens collected in his study of the erratic phenomena of the Alps which he brought with him to the country. The specimens are so displayed in cases that, in connection with maps in the room, they teach "the extent, thickness, limits, and courses of the great ice-mass that once covered all Switzerland." Guyot, besides, found much gratification in the successful work of his pupils in Rocky Mountain exploration and the large additions to the collections thus secured. The memoir of Guyot by William Libbey, Jr., vice-director of the museum, speaks of the museum as the most substantial monument that Prof. Guyot has left behind him in Princeton.

Meteorological and Geographic Work, 1849 *to* 1881.—At the Philadelphia meeting of the American Association in 1848, where Guyot

* With the consent of Mr. Price, this chair was subsequently fully endowed by and named for Mr. John J. Blair, of New Jersey.

went with Agassiz soon after reaching the country, he met Prof. Henry, of the Smithsonian Institution, and this meeting was soon followed by the perfecting of plans for a national system of meteorological observations. Guyot was charged by Prof. Henry with the selection and ordering of the improved instruments that were required; and among his changes he rejected the old barometers in favor of the cistern barometer of Fortin as improved by Ernst and further improved in accordance with his own suggestion as regards safety of transportation, making what is now the Smithsonian barom, eter. He also prepared directions for meteorological observations which were published by the Institution as a pamphlet of forty pages in 1850, and a volume of meteorological and physical tables, which was printed and distributed in 1852. The latter very important work was afterward enlarged and became, in the edition of 1859, a volume of 634 pages, containing over 200 tables admirably arranged and adapted for the best meteorological and hypsometric work.* A letter of his to Prof. Henry in 1858 says that two-fifths of the pages of tables, representing 68,000 computed results, were wholly new and were prepared for the volume. He adds: "It is essentially a work of patience, in doing which the idea of saving much labor to others and facilitating scientific research is the only encouraging element."

One important part of Guyot's meteorological labors consisted in the selection and establishment of meteorological stations. With this object in view, he made in 1849 and 1850, under the direction of the Regents of the University of New York in conjunction with the Smithsonian Institution, a general orographic study of the State of New York in order to ascertain the best locations for such stations. Thirty-eight stations were then located by him at points widely distributed over the State; and, at the same time, patient, earnest Guyot took pains to instruct observers at the stations in the use of the meteorological instruments. Similar work was also done under like auspices in the State of Massachusetts. The report of the Regents of the University of New York for 1851 contains the topographical results of the exploration, giving an excellent sketch of the high plateaus and the larger valleys of the State.† The exploration in

* The volume of tables is No. 538 of the Smithsonian Publications. In 1862 it received from its author a further addition to its tables of 70 pages and in 1884 a new and enlarged edition, in preparation since 1879, was issued

† Reprinted in the American Journal of Science, 2d Ser., XIII, 272, 1852

1849 extended into the depth of winter, and his long journeys, in that inclement season, were often over unbroken roads and in the roughest of conveyances.

Thus Guyot went almost immediately to work in his favorite fields, laying the foundations not only for geographical education, but also for geographical investigation, and for a national system of meteorological observations and records. The national plan was not then inaugurated; but the work thus carried forward under the Smithsonian Institution was the initiator, in fact, of the United States Signal Service Bureau.

In the summer of 1861 Guyot had occasion to visit Europe, and he took advantage of the opportunity, observes Prof. Henry, "to determine, by his own observation, the relations of the standard barometers used by the Smithsonian Institution with the most important standards of the European observatories; and it is believed that these comparisons establish a correspondence of the European and American standards within the narrow limit of one or two thousandths of an inch."*

Besides the general survey of New York topography, Guyot carried forward, during his leisure weeks of the summer and autumn, a study of the altitudes and orography of the Appalachian Chain, or the mountain system of Eastern North America, in which work he had encouragement from appropriations by the Smithsonian Institution. He commenced, as early as 1849, a barometric exploration of the White Mountain system of New Hampshire, and continued his work at the North until he had spent five years over New Hampshire, the Green Mountains in Vermont, and the Adirondacks, and other parts of New York.

From these more northern portions of the Appalachian system he went to Virginia and North Carolina. In July of 1856 he measured barometrically twelve of the highest peaks of the Black Mountains in North Carolina, all of them higher than the White Mountains of New Hampshire. He was occupied with this southern part of the system from that time till late in the summer of 1860,

* Prof. Henry's Report to the Regents of the Smithsonian Institution for the year 1862. The observatories with which the comparisons were made were that of Kew, then under the direction of Stanley; that of Brussels, under Quetelet; that of Berlin, under Encke, and that of Geneva, under Plantamour, who had already compared the Geneva barometer with that of the Collège de France and that of the Observatory of Paris.

when his measured heights in that region of endless forests and great altitudes had increased in number until they exceeded 180; how much exceeded his paper does not say, as the altitudes determined in 1860 remain still unpublished. Besides these measurements, he made his survey complete by extending a net work of triangles over the area (nearly 150 miles in length), so fixing the positions of the peaks and ridges.

In a letter of October 3d, 1859, he writes, speaking of his work of that season in the Smoky Mountains, "the culminating range of North Carolina:" "My trip to the Smoky Mountains was a long and laborious one. Much rain, great distances, imperviable forests, delayed me two months. I camped out twenty nights, spending a night on every one of the highest summits, so as to have observations at the most favorable hours. The ridge of the Smoky Mountains I ran over from beginning to end, viz: to the great gap through which the Little Tennessee comes out of the mountains."

Having thus far finished his study of the mountain system, a new map of the whole Appalachian chain, made under his direction by his nephew, Mr. Sandoz, was published in 1860, in the July number of Petermann's "Mittheilungen." This map, with some emendations, was republished in 1861, in volume XXXI (Second Series) of the American Journal of Science, in illustration of an accompanying paper on the Appalachian system. This paper, after a brief history of his work, presents his results in an orographic description of the mountain region and an explanation of the laws which he had deduced, together with tables of more than 300 altitudes.

His "thousands of measurements" in the Alps had prepared him for accurate and thorough work here. As evidence of exactness, his barometric measurement of Mt. Washington in 1851 gave for the height 6,291 feet; the measurements by spirit-level made by N. A. Godwin, civil engineer, in 1852, gave 6,285 feet, and a similar leveling under the direction of the Coast Survey in 1853 gave 6,293 feet. So, again, the Black Dome of North Carolina, made 6,707 feet by him, was measured with a spirit-level by Major J. C. Turner, civil engineer, setting out from Guyot's point of departure, and the height made 6,711 feet.

There were still left unmeasured the heights of the Catskill Mountain range. In 1862 he went to work in this region, and continued it, as before, during his summer and autumn vacation months until the close of the summer of 1879, excepting the year 1871, when he

took a trip to California for his health and some barometric work in the Rocky Mountains and the Coast Range. Gray's Peak, in Colorado, was one of the heights ascended and measured—an easy walk for *him*, said the young men of the party.

The Catskill region, a plateau of "piled-up strata owing its mountain forms chiefly to sculpturing waters," had its difficulties. Although so near New York and the Hudson river, and frequented each summer by thousands of tourists, it was to a large extent, especially over the southwestern part, an untracked wilderness of forests. In several cases his only chance for making his triangulation was by climbing to the tops of the highest trees, and then there was difficulty in identifying the distant, featureless, forest-buried summits. Moreover, many peaks had no names, and, again, the same name was often found to be used for two or three different peaks. He accomplished his work nevertheless, and when finished had gratifying proof of his great accuracy in spite of the difficulties. One point in the triangulation, the extreme western, was in common, as he afterward found, with that of the State survey of New York, under Mr. James T. Gardiner; and "in the position of this station," he says, writing August 12th, 1849, "we agree perfectly."

He discovered, by his explorations in the Catskills, nineteen summits that were higher than the highest previously known, three of them over 4,000 feet above tide-level. For the highest, called "Slide Mountain," he found the elevation 4,205 feet, while that of "High Peak," which had been thought the highest, proved to be only 3,664 feet.

This work closing so grandly Guyot's study of the Appalachian System—begun by him when he was 42 years of age—was finished in 1881 when 74. It was his "vacation" work. His memoir on the Catskills was published in 1880 in volume XIX (3d series) of the American Journal of Science, with two illustrating maps. The orographic structure of the range is described, its origin briefly and judiciously considered, and the heights given for over 200 points. A larger map (14 x 20 inches) was issued the year before as a pocket map. And thus his orographic labors have already contributed greatly to the convenience of tourists as well as to geographical science.

Guyot's first scientific work, fifty years since, and his last was mountain work. And I think I am safe in saying that no one before him, if any since, can claim to have made with the barometer

more numerous and more accurate hypsometric measurements; his field books make the number of such measurements by him over twelve thousand. In all his explorations he manifested that unflagging energy and thoroughness which are required for accurate work. At the same time his acuteness of intellect and well-furnished mind, while demanding the fullest investigation for final results, led him quickly and surely in the path toward right conclusions, as was strikingly manifested in the outcome of those six weeks in 1838 over the glaciers. Besides these qualities of the careful and judicious observer his ever-searching mind, as shown by his comprehensive views on the earth, living nature, and man, was remarkable for its powers of philosophical analysis and generalization. The combination of the thorough student of facts in nature with the far-seeing student of principles and fundamental law has seldom been more complete, and we may therefore well describe him as in a remarkable degree—using his own language—"a harmonic unit."

The two friends from Switzerland, Guyot and Agassiz, were both needed by the country when they reached its shores. Each performed a work among us of great service to education as well as to science, and we owe them lasting gratitude. But their change of base in coming to America gave them a position for wider influence over the world, and American gratitude is not all that is due them.

In recognition of Guyot's services to science he was elected to honorary membership in several learned societies, among them the Geographical Society of London, and that of Paris; and since his decease a Geographical Society has been organized at Neuchâtel, this being, in the words of Prof. Louis Favre, "the finest monument that could be erected to the memory of a savant who had brought so much honor to his native land."

In 1867 Guyot married a daughter of the late Governor Haines, of New Jersey, a lady of intelligence and refinement, who made for him the happiest of homes; and his gentleness, consideration, and warmth of heart fitted him to contribute his share to that happiness.

Guyot's face and manner betokened deep and earnest thought rather than enthusiasm and quiet self-possession without self-assertion. A man of medium height, deep-set eyes, and spare figure, he looked as if made more for thinking than for acting, and yet his power of walking and climbing seems to have had no bounds, and

scarcely failed him at all until after his three-score and ten had been passed. The greatest ascents gave his well-trained muscles no more fatigue than a walk in his garden; and pathless tangled forests for weeks in succession, with nights in the wild woods, were a source of great enjoyment. On the 29th of December, 1883, hardly six weeks before his decease, he wrote to the President of the Society of Natural Sciences of Neuchâtel, M. Coulon, after congratulating him on keeping up his walks to Chaumont, although then eighty years of age, "Even last year I could have told you of my seventy-six years and my ability still to climb our mountains, but unhappily it is not so now." *

His special weakness was a virtue in excess, an unobtrusiveness that disinclined him to assert himself, that made him too easily content with work without publication. Hence his results and original views often failed of recognition, and but one of his projected works of the higher series was ever completed. In a letter of November 15, 1858, in replying to one who had urged him to publish, he says: "And I am A. G., who thinks a good deal and delights in it, but is too easily satisfied with that selfish pleasure." Yet much of this reluctance was, as before said, owing to the hesitation of his critical mind in the use of the English language. Besides, he was ever waiting for more facts. And, too, he was overburdened, as he often said, with his educational labors. In accordance with his unassuming ways, de did not become a naturalized citizen of his adopted country until 1860, he feeling, rather than reasoning, that a foreigner should not hasten to intrude himself into political affairs.

Although indisposed to push himself, still, when in conversation with a man of like intelligence, he was sure to command eager attention, and, without other effort, to find places of honor and congenial work open to him. Within six months of his arrival in the country, a talk, in Philadelphia, with Prof. Henry gained for him the position of a virtual manager in the Meteorological Department of the Smithsonian Institution, and, by similar means, there came about his connection with the Massachusetts Board of Education. Through his wealth of ideas, not self-effort, he secured the several high positions occupied by him in the country.

Guyot was a man of devoted friendships. He manifested this

* Memorial sketch of A. Guyot by Prof. L. Favre, Vice-President, Bull. Soc. Sci. Nat. Neuchâtel, XIV, 327, 1884.

deeply in his tribute to his old teacher, Carl Ritter, and in that to his compatriot, Agassiz. There was no limit to his good-will. Children of his acquaintence knew this, and all who had the privilege of intercourse with him. On the 7th of November, 1864, he writes from Princeton, "I have bought the house in which I live, and my care has been to prepare and shape the garden for the next season according to my taste. A quiet green retreat to study and write, and good friends visiting me in it and filling it with the warm rays of affectionate friendship, is an ideal for which, if realized, I should heartily thank God."

Guyot was a fervently religious man, living as if ever in communion with his Heavenly Parent; a Christian, following closely in the footsteps of his Master. His search into nature's phenomena and laws was a search for divine truth and a divine purpose. His field-notes of 1850 contain the entry: "On n'est fort qu' avec la vérité, et ce que m' importe c' est de l' avoir de mon coté. Dieu sait que je la désire avant tout, et il me fera la grace de la reconnaitre." In his trip to Europe in 1861 he went as a delegate from the Presbyterian church of America to the convention of the Evangelical alliance which met that year in Geneva. He writes from Paris, under date of October 24th, just before his return, of his "great pleasure in attending, in that old stronghold of Protestant faith, the large and exceedingly interesting meeting," and in witnessing the "grand spectacle of so many sympathizing Christians from all quarters of Christendom uniting in the services with perfect freedom and unanimity." And then he shows his kindly nature in allusions to "the testimonies of love and true friendship" which had greeted him everywhere in his journey through Europe and the land of his youth, and in expressions of thankfulness "for those old affections" and those "deep sympathies which are destined, by their very nature, to outlive our mortal frames."

His Neuchâtel pupil, Mr. Faure, well observes: "He cared little for renown, but much for the study of nature and for the education of man." As fellow-students, we have special reason to admire in Guyot—as he wrote of Humboldt—"that ardent, devoted, disinterested love of nature which seemed, like a breath of life, to pervade all his acts; that deep feeling of reverence for truth so manifest in him which leaves no room for selfish motives in the pursuit of knowledge, and finds its highest reward in the possession of truth itself."

Arnold Guyot died at Princeton on the 8th of February, 1884. Funeral services were held in the church, where the officers and students of the college and other friends were gathered with the relatives of the deceased, and excellent memorial discourses were pronounced by Rev. Horace Hinsdale and Dr. James Murray, dean of the college. His remains lie buried in the Princeton Cemetery.

LIST OF THE WRITINGS OF PROF. ARNOLD GUYOT.

1835. Inaugural Dissertation, at Berlin, on the Natural Classification of Lakes. (In Latin.)

1835. Numerous contributions to the Encyclopédie du XIXéme Siècle, Paris. Among them the more extensive are on Germany, Physical Geography of Germany, and on the System of the Alps.

1838. On the Structure of Glaciers and the Laws of Glacier Motion. Read before the Geological Society of France in 1838, but not published until 1883.

1842. On the Ribboned Structure of the Glacier of Gries. From the paper of 1838. Read before the Soc. Sci. Nat. de Neuchâtel, December 1, 1841, and published in abstract in the Verhandl. d. Schweiz Nat. Gesellschaft, Altdorf, 1842, pp. 199, 200. Published in full, excepting the last part, in New Phil. J., Edinburgh, XXXV, 1843, in a paper on Agassiz's Glacial Researches, by Desor; also in Tyndall's Glaciers of the Alps (1856), and his Forms of Water (1872); also in full in Agassiz's Système Glaciare (1847).

1842. Observations on the Erratic Phenomena of Lower Switzerland and the Juras. Verhandl. d. Schweiz Nat. Ges., Altdorf, for July, 1842, pp. 132–145.

1843, '45, '47. Observations on the Erratic Phenomena of Switzerland. Bull. Soc. Sci. Nat., Neuchâtel, for November, 1843, May and December, 1845, and January, 1847.

1844. On the Law of the Formation and Distribution of Glacier Crevasses.

1847. Erratic Phenomena in the Alps: abstract in D'Archiac's Hist. Progr. Géol., Vol. II, pp. 259–265.

1849. Earth and Man, or Lectures on Comparative Physical Geography in its Relation to the History of Mankind. 310 pp. 8vo. Boston. Second edition in 1850.

1850. On the Upheaval of the Jura Mountains by Lateral Pressure. Proc. Amer. Assoc., II, 115. Read before the Association in August, 1849.

1850. Directions for Meteorological Observations. For the observers of the Smithsonian system of meteorological observations.

1852. Meteorological and Physical Tables. 212 pp. 8vo. Prepared for and published by the Smithsonian Institution. A second edition in 1859, 639 pp.; received an addition of 70 pages in 1862; a third edition in 1884, — pp.

1852. On the Topography of the State of New York. Rep. Regents Univ. New York for 1851, p. 232. Albany. Reprinted in Am. Jour. Sci., 2d Ser., XIII, 1852.

859. Address at the Humboldt Commemoration of the American Geological Society, in October, 1859. Jour. Amer. Geogr. and Statist. Soc., I, No. 8, 1859, pp. 242–245.

1860. Carl Ritter: an address to the American Geographical Society, February 16, 1860. Jour. Amer. Geogr. Soc., II, No. 1, 1860, pp.25–63.

1861. On the Physical Structure of the Appalachian System of Mountains, with a physical map of the system. Amer. Jour. Sci., 2d Ser., XXXI, 157.

1861. Altitudes in North Carolina and Georgia. Geol. Rep. North Carolina of 1861, and also of 1875.

1866–'75. A series of School Geographies, six volumes, including a Physical Geography. A series of wall maps, containing thirty maps.

1873. A Treatise on Physical Geography, Johnson's Family Atlas of the World.

1874. Cosmogony of the Bible, or the Biblical Account of Creation in the Light of Modern Science. Rep. of the Sixth Gen. Conference of the Evangelical Alliance, in New York, 1873.

1874–'77. Many articles in Johnson's Encyclopædia, of which Prof. Guyot was one of the editors-in-chief.

1875. Memoir of James Coffin. Read before the National Academy of Sciences.

1877–78. Memoir of Louis Agassiz. Read before the National Academy of Sciences, October 23, 1877, and April, 1878. Published at Princeton. 50 pp. 8vo. April, 1883.

1879. Physical and Orographic Map of the Catskill Mountain Region; size, 14 x 20 inches.

1880. On the Physical Structure and Hypsometry of the Catskill Mountain Region, with two plates. Amer. Jour, Sci., 3d Ser., XIX, 429. Communicated to the National Academy of Sciences in part at sessions in 1875 and 1876.

1883. On the Existence in Both Hemispheres of a Dry Zone and its Cause. Amer. Jour. Sci., 3d Ser., XXVI, 161. Read before the National Academy of Sciences, November, 1882.

1884. Creation, or the Biblical Cosmogony in the Light of Modern Science. 136 pp. 12mo. New York.

PAPERS COMMUNICATED TO THE NATIONAL ACADEMY, BUT NOT DEPOSITED IN MANUSCRIPT.

August, 1864. At the meeting at New Haven. On the influence of the hour of the day on the results of barometric measurements of altitudes.

August, 1865. Northampton. On the probable cause of the Glacial Epoch of the Post-tertiary.

August, 1866. Northampton. On the influence of the hour of the day on the heights obtained by barometric measurements.

January, 1868. Washington. On the practical character of the usual thermometric scales, and a common substitute for them.

August, 1869. Northampton. On the law of distribution of volcanoes and its bearing on the theory of volcanic action.

April, 1873. Washington. On the altitude of Gray's and Torrey's Peaks, in Colorado; some questions connected with the determination of barometric altitudes in the interior of continents.

On the unity of the system of life in animals and the true principle of gradation in the various animal types.

MEMOIR

OF

JOHN WILLIAM DRAPER.

1811-1882.

BY

GEORGE F. BARKER.

Read before the National Academy, April 21, 1886.

BIOGRAPHICAL MEMOIR OF JOHN WILLIAM DRAPER.

Mr. President and Gentlemen of the Academy:

The growth of science during the last half century is nowhere better illustrated than in the changes which have taken place in our views with regard to the doctrine of energy. Fifty years ago the imponderables held full sway and heat light and electricity were considered forms of matter quite as much as oxygen and sulphur and iron. True here and there an advanced thinker offered his protests against this conception and even made experiments to prove its fallacy; but it was not until 1844 that Melloni established the essential identity of radiant light and heat, and not until 1850 that Foucault made his *experimentum crucis* with regard to light. No one in America, it is believed, had a larger share in contributing to this entire revolution of scientific opinion than the eminent man who is the subject of this notice. For more than forty years he labored earnestly, persistently, successfully in the field of radiant energy. Viewed from the standpoint of to-day much of his work may be criticised, of course; but, as he himself has said, to an observer "imbued with the true spirit of philosophy even the shortcomings which are detectable in it are not without a charm. From the better horizon he has gained he watches his author, who, like a pioneer, is doubtfully finding his way, here traveling on a track that leads to nothing, then retracing his footsteps, and again, undeterred, making attempts until success crowns his exertions. To explore the path to truth implies many wanderings, many inquiries, many mistakes."

John William Draper was born in the parish of St. Helens, near Liverpool, England, on the 5th of May, 1811. His father, the Rev. John C. Draper, was a clergyman of the Wesleyan denomination and, like others in the same calling, was in quite moderate circumstances. He was always greatly interested in scientific subjects, however, especially in chemistry and astronomy, and owned a Gregorian reflecting telescope, with which he made

many observations. Young Draper received his earlier education in his own home from private tutors employed for the purpose; but at the age of eleven he was sent to a public school at Woodhouse Grove, then supported by the Wesleyans. The head master of this school was an American. He was a man of considerable literary ability and had contributed several articles of note to Rees' Encyclopedia, an authority then in great repute. Here young Draper devoted himself assiduously to his classical and mathematical studies and with marked success. So that, in recognition of the progress he had made in scholarship, he was selected in 1824 to deliver the customary address from the school to the Wesleyan conference, which met that year at Leeds. This was his first public oration and it made a great impression upon him. Not long after this event, however, he left the Woodhouse Grove school and returned home, continuing his studies there, as before, under private tutors.

In the year 1829 the University of London was opened for instruction. The professor of chemistry in the new institution was Dr. Edward Turner, a man whose reputation as a chemist placed him among the first in England. Young Draper, who, with his other studies, had taken up the study of science and had already developed a decided taste for investigation, was sent to Dr. Turner's laboratory to receive a course of instruction in chemistry. During the two or three years which were thus occupied a pleasant and profitable acquaintance was engendered, which ripened into a lifelong friendship. Owing to the unexpected death of his father, however, he did not take a degree at the University.

Before the Revolutionary War certain of Draper's ancestors on his mother's side had come to America and had settled in Virginia, founding a small Wesleyan colony. Subsequently others of the family had crossed the ocean and joined the colony. Urged by these relatives and accompanied by his mother and sister Draper came to America in 1832, in his twenty-second year. The expectation of receiving a professorship in the denominational college in the vicinity was one of the strongest inducements held out to him. Repeated delays in starting, however, made the time of his arrival much later than had been anticipated; so that, when he reached Virginia, the position he had hoped for had been given to another person. He settled with his relatives at Christiansville, Mecklenburg county, where he devoted himself entirely to scientific research.

Although before leaving England he had published, jointly with

a Fellow of the Geological Society, three papers on scientific subjects, yet his first independent contribution to science was from this Christiansville laboratory. It appeared in the American Journal of Science and Arts for July, 1834, in the form of a letter to the editors, the memoir *in extenso* appearing in the September number of the Franklin Institute Journal for the same year under the title "Some experimental researches undertaken to determine the nature of capillary action." During this period he devoted his attention also to improvements in the construction of galvanic batteries, to investigations on the alleged magnetic action of light, and to the analysis of a native chloride of carbon and of certain ancient coins and medals.

Having decided to take the degree of Doctor of Medicine in course Draper spent the winters of 1835 and 1836 in Philadelphia attending the medical lectures given in the University of Pennsylvania. Here he came directly under the congenial and stimulating influence of Dr. Robert Hare's instruction in chemistry and physics, and in him and in Dr. J. K. Mitchell, at that time the professor of chemistry in the Jefferson Medical College, he found warm personal friends. In their laboratories he did a large amount of scientific work, and this not only alone, but also conjointly with these eminent men. He assisted Dr. Mitchell when he used for the first time in this country the apparatus of Thilorier for the liquefaction of carbonic-acid gas.

Draper graduated from the University in March, 1836. The subject of his thesis, as given in the Alumni Catalogue, was "Glandular Action." It discussed the passage of gases through various barriers not having visible pores, such as soap bubbles. He showed that these transfusions take place as instantaneously as if there was no obstacle in the way and are attended by many curious phenomena. He put one gas inside the bubble and another on the outside; he then analyzed both and showed that the movement continues until the gaseous constitution is the same within and without the bubble. The special application of these experiments was to ascertain what goes on in the air cells of the lungs; how oxygen is introduced into the blood and carbonic acid escapes from it in the act of inspiration. Current report has it that the scientific character of this thesis secured for it the special commendation of the medical faculty and the high honor of publication at their hands. But as the thesis itself is missing from the collection of the class of 1836, preserved

in the college records, and as no such title as the above appears in any of his published papers, it has been found impossible to verify the statement. Two papers, however, covering much the same ground appeared shortly afterward. The first, "Experiments on Endosmosis," came out in the Journal of the Franklin Institute for March and July. The second, entitled "Experiments on Absorption," which was much more extended, was printed in the American Journal of the Medical Sciences for May.

The published scientific memoirs of Dr. Draper had now won for him a very considerable reputation. His graduating thesis had by its originality and by the experimental ability shown in it attracted the attention of the authorities of Hampden Sidney College, Prince Edward county, Virginia. Accordingly, in the fall of 1836, he was tendered, and accepted, the professorship of chemistry and natural philosophy in that institution. This appointment was especially agreeable to him, since it enabled him, as he said, "to convert experimental investigation, thus far only an amusement, into the appropriate occupation of his life." In the new sphere of labor thus opened to him he continued his scientific researches with largely increased experimental facilities.

In 1837 a movement was made to establish a medical school in connection with the University of the city of New York, and Dr. Draper was elected professor of chemistry in the new institution. The financial embarrassments of that year, however, crippled the university and the project was temporarily abandoned.

In 1839, however, he was elected professor of chemistry in the undergraduate department of that university, and removed with his family to the city of New York. In 1840, in conjunction with Drs. Mott, Bedford, Pattison, and Revere, he took an active part in organizing the medical department, in which he became the professor of chemistry. His intimate relations with the chancellor, the Hon. Theodore Frelinghuysen, resulted in his assuming a large share in the preparation of the constitution of the new department, to the wise provisions in which its subsequent prosperity has been largely due. Moreover, in doing this he exerted a marked influence on the development of medical science in the city of New York. At that time there were but few medical students there, probably not more than forty or fifty. But in the session of 1841–'42 the University Medical School alone enrolled 239 students, and the number in attendance at the College of Physicians and Sur-

geons was also largely increased. The new movement was, from the first, greatly indebted to the influence exerted in its favor by the New York *Herald;* and this arose out of the relations of personal friendship which existed between Dr. Draper and Mr. James Gordon Bennett. To these gentlemen, it has been said, more than to any others, New York owes its present advanced position as regards medical education. Entire pages of the *Herald* were devoted to reports of the lectures and clinics at the University; and a strictly medical journal, published by Mr. Bennett and called *The Lancet*, kept the doings of the University school constantly before the medical profession.

The first president of the new medical college was Dr. Valentine Mott, who was also professor of surgery. Dr. Draper was elected secretary. In 1850, upon the resignation of Dr. Mott, he succeeded to the presidency, and by his active measures and wise counsels, inaugurated a period of unexampled prosperity for it. In his own instruction Dr. Draper had always maintained that the functions of an organized being were performed under the operation of chemical and physical law, in opposition to the theory of vital force then in vogue among physiologists. And now, when the new views of Liebig and his school gave increased importance to the chemical relations of physiology, he was among the first to recognize their value, and, as a consequence and at his request, physiology was added to his chair. He resumed his researches on physiological subjects, and his lectures were replete with novel and radical ideas.

One of the severest trials through which the medical department was called to pass during Dr. Draper's presidency was the entire destruction by fire, in 1865, of its college building in Fourteenth street. But the same untiring energy which had secured the edifice that was destroyed not only made prompt provision for the continuance of the lectures, but speedily repaired the loss. Though in the midst of the course of instruction, not a single lecture was lost; and in the fall of 1869 he gave the introductory lecture of the course in the new building, which is still occupied by the school, and which had been provided, as he told the class, by the generosity of Mr. Courtlandt Palmer.

Dr. Draper's personal loss was especially severe. Not only were his extensive library, his lecture notes, and the note-books which contained the results of his experimental investigations consumed, but his entire collection of chemical, physical, and physiological

apparatus, that used to illustrate his lectures as well as that more valuable portion which he had used in his researches, was destroyed. The pecuniary loss he estimated at $15,000. This was the second time he had suffered severely by fire. In 1853 almost the entire edition of his scientific memoirs and essays up to 1844, together with the illustrative plates, were destroyed by fire in the publishing house of Harper & Brothers.

In 1873 Dr. Draper severed his connection with the medical department of the University, but continued his instruction in chemistry to the undergraduate classes until 1881, the year preceding his death.

It has been already stated that Dr. Draper developed very early in life a decided fondness for science and scientific investigation. It is said that his decision to devote himself to the experimental study of nature arose from the accidental observation that in a glass vessel containing camphor beautiful crystals had condensed only on the illuminated side. A desire to understand the cause of this phenomenon led him to read whatever books he could obtain which treated of the chemical and mechanical action of light, of adhesion and of capillary attraction, and subsequently to experiment for himself in these and similar subjects.

Capillary attraction was the subject of his first extended research. Clairaut had already shown that the phenomenon was due to the adhesion of the solid for the liquid as compared with the cohesion of the latter, and that if the mutual attraction of a solid and a liquid amount to half the cohesion of the liquid there will be capillary depression; but that if this attraction be greater than half the cohesive value the liquid will rise in the tube. Dr. Young had maintained that the bounding meniscus of a liquid was an elastic surface and acted by its tension to elevate or depress the column which it terminated. And Laplace, in the more elaborate memoir contained in his Théorie de l'action Capillaire, published in the supplement to the tenth book of his Mécanique Celeste, had attributed the rise or fall of liquids to the attraction of a thin layer of the liquid immediately adjacent to the walls of the tube. Dr. Draper's attention was first drawn to the subject, as he tells us, during those tiresome moments of returning health which follow an autumnal fever. "Perhaps," he says, "if there be any merit in these experiments it may hereafter be of service to some one to know that they were begun in sickness and in a land of strangers; that they

were pursued in all the calamity of family bereavement, and in the depths of forests, alike unused to music, to poetry, to philosophy." His first experiments were addressed to the direct determination of the attraction between mercury and glass, with the view of testing Clairaut's mathematical deduction. After repeated trials he found that a strong and uniform adhesion was obtained when the mercury was pure and warm and the glass perfectly clean. Repeating the experiment with an amalgamated disk of copper, of the same size, the weight required for separation was regarded as measuring the cohesion of the mercury itself. The results of a number of experiments showed that in no case did the attraction of mercury for glass amount to half the cohesion of the mercury. But since a glass plate on the surface of water is wetted, even after separation, it is obvious that in this case the adhesion is greater than the whole cohesion; hence the rise of water in a tube of glass is easily accounted for.

But an unexpected phenomenon was developed. On connecting the mercury, dry and warm, to a gold leaf electroscope no disturbance of the leaves took place so long as the glass plate was in contact with its surface. But on separating them—and it required considerable force to do this—both the mercury amd the glass became strongly electrified, the mercury being negative and the glass positive. Indeed, the development of electrification was so decided as to tear asunder the leaves of the electroscope. Dr. Draper naturally concluded that contact of mercury and glass developed electrification; that while in contact the electricity was "disguised" and appeared only on separation; and that since the two were oppositely and strongly electrified, the force required to separate them measured the electrical attraction. But this force measured also the adhesion, by hypothesis; and hence adhesion must be an electrical attraction. Two striking confirmations of this theory are given in the memoir. In the first he repeated the mercury experiment with disks of glass, gum-lac, sealing wax, sulphur, and beeswax, and proved that the electrification, as measured with the torsion balance, was for each disk proportional to the adhesion as measured by the force required for separation; and that for the several disks examined the values obtained diminished in the above order. In the second he showed very ingeniously that electrification exercises an apparent control over all the phenomena of capillary attraction. One form of his apparatus consisted of an inverted siphon, the

larger leg being about half an inch and the smaller about one-tenth of an inch in diameter. Mercury is poured into the larger and dilute sulphuric acid into the smaller tube, the latter liquid resting on the former. On connecting the mercury with the negative terminal of a voltaic battery and the acid with the positive the mercury falls in the tube. Reverse the battery-terminals and the mercury column rises. Moreover, Dr. Draper observes that all these changes in position are accompanied by certain definite changes of figure of the bounding surface, and shows that this might have been expected from the theory of Laplace. Placing a globule of mercury in acidulated water in contact with the negative terminal of the battery he found that whenever contact of the positive terminal was made with the acid an instant deformation of figure took place, the upper surface being flattened, so that the mercury touched the inclosing tube all around in a complete ring. This memoir, published in 1834, must be considered in all respects a remarkable one, and anticipates clearly many of the more important later discoveries.

The phenomenon of osmose described by Dutrochet in 1827 had been noticed by Dr. Draper in the above memoir. A few years later Dr. J. K. Mitchell had published a valuable paper on the osmotic phenomena observed in membranes of caoutchouc. When Dr. Draper entered upon his medical studies in Philadelphia, therefore, it was natural that he should take a lively interest in the phenomena referred to, and particularly in their physiological relations.

His experiments on gaseous osmose were original and important and were based on the simple assumption that any substance in contact with any other tends to diffuse into it. He found that ammonia gas penetrated almost instantly films of shellac, gold leaf and mica, and especially liquid films, whether these were thin, as in a soap bubble, or were composed of a layer of water of quite considerable thickness. When such a layer separated carbonic-acid and hydrogen gases, for example, he observed that the phenomenon was a simple one and consisted in the mutual solution of the gases in the liquid, their transference through the film, and their subsequent evaporation, the process ceasing when the atmosphere on both sides of the layer was the same. Using then a membrane of caoutchouc he sought to discover whether gaseous osmose could be prevented by pressure; and he experimentally proved that sulphurous acid passed into air under a pressure of 7⅓ atmospheres, car-

bonic acid under one of 10 atmospheres, and hydrogen sulphide under a pressure of 24¼ atmospheres. Since the force impelling the particles of one gas into the interstices of another, without a septum, never exceeds the pressure of one atmosphere, it is plain that the source of this remarkable power must lie in the membrane itself. So that the caoutchouc membrane must, in this experiment, have condensed the sulphurous-acid gas and the hydrogen-sulphide gas into liquids, which were then, in this condition, transferred through the film and evaporated on the other side precisely as with the water film.

With regard to liquid osmose Dr. Draper shows that the only essentials are: First, that both the liquids should wet the barrier; second, that they should rise to different heights in tubes made of it, and, third, should be capable of uniting chemically with each other. All solid bodies which act as barriers have pores, which, while too small to permit leakage, yet allow interchange of indefinitely small columns of liquid. Such are plates of Villarica porcelain clay, of Brazil indurated steatite, and of certain varieties of compact sandstone. No liquid can pass a barrier the pores of which it cannot wet; but, since water by electrifying it positively may be made to wet mercury, electricity modifies osmose. The separation of water from litmus through a membrane having alcohol on its other side, he concludes, is "only a refined kind of filtration, which, probably, may hereafter become of considerable importance in its applications in the arts, as in the separation of coloring matter from solutions, or the preparation of medicines, such as the vegetable alkalies, which should be formed from colorless solutions."

In a paper published in 1846 Dr. Draper applies these principles very ingeniously to explain the circulation of the sap in plants and the blood in animals. Both these motions, he says, depend on the following simple physical principle: "That if two liquids communicate with one another in a capillary tube or in a porous or parenchymatous structure and have for that tube or structure different chemical affinities movement will ensue; that liquid which has the most energetic affinity will move with the greatest velocity and may even drive the other fluid entirely before it." In the rootlet the phenomenon is simply an osmotic one, a flow taking place from the water without into the mucilaginous sap within, precisely as water flows into gum-water through a bladder. In the leaf the weak ascending watery sap rises to its upper surface and there obtains

carbonic acid from the air. The sunlight effects the decomposition of this, changing it to a mucilaginous solution. On the principle now indicated the water will drive the mucilaginous solution before it, forcing it back along its proper vessels into the stem. The flow of the sap in plants therefore is controlled by sunlight, since this agent determines the production of the mucilaginous solution, which is the motive power. When the season advances the flow slackens, because the formation of the elaborated sap diminishes. Both in the rootlet and in the leaf consequently the action is due to the fact that two different liquids are brought in contact with a porous solid, which is wetted by both of them, but unequally. Hence that one which has the greatest affinity for the solid and wets it most perfectly passes most rapidly through it and drives the other one before it. The descent of the elaborated sap is therefore quite as positive an action as the ascent of the unelaborated.

In animals the blood in the arterial capillaries of the systemic circulation is charged with oxygen, which has an intense affinity for the carbon and hydrogen of the walls. In the venous capillaries the blood is charged with carbonic acid having no affinity for these tissues. The arterial blood will drive the venous blood before it, therefore. In the pulmonic system the venous blood is presented to the air cells, for the oxygen in which it has a strong affinity, while the arterial blood which has absorbed this oxygen has no longer any. Movement ensues as before, but as now the affinities are reversed the flow is from the veins to the arteries. The systemic circulation is due therefore to the oxidizing action of the arterial blood and the flow is from the artery to the vein. The pulmonary circulation is due to the oxidation of the venous blood and the flow is from the venous to the arterial side. Both arise from the common principle that "a pressure will always be exerted by the fluid which is ready to undergo a change upon that which has already undergone it—a pressure which, as there is no force to resist it, will always give rise to motion in a direction from the changing to the changed liquid."

"A true theory," says Dr. Draper, "is like a window of crystal glass, through which we can see all objects in their proper positions and colors and relations, no matter whether they are such as are near or those that are at a distance; no matter whether they are directly before us or enter only obliquely into the field of view. A fictitious theory is like a venetian blind, which has to be set in a

certain position with respect to the observer and only shows him objects for which it has been adjusted, and those in an unsatisfactory manner; but if he moves to one side or to the other, or endeavors to see objects which are not directly in his way, his view is intercepted, or, perhaps, unless he makes a new adjustment, the light is shut out altogether."

It is, however, by his researches upon Radiant Energy that John W. Draper is best known in the world of science. In an able memoir on the Production of Light by Heat, published in 1847, he described some ingenious experiments with incandescent platinum, by which he conclusively proved: First, that the temperature at which this metal became incandescent was fixed and constant at 977° F.; and, second, that various other substances, such as brass, antimony, gas carbon, lead, and the like, all became luminous at the same temperature, which was that of the gun barrel in which they were inclosed. By means of an extemporized spectroscope he examined the platinum as its temperature was gradually raised by the electric current and showed that as this temperature rose from 1,095° to 2,130° F. the spectrum gradually extended itself toward the violet; rays of an increasing refrangibility being successively produced, the frequency of the vibrations increasing with the temperature. In order to bring these observations to a common standard of comparison Dr. Draper originated the simple device of using the sun spectrum with its fixed lines as a reference-spectrum, daylight being reflected to the prism through a narrow aperture occupying exactly the position in which the platinum strip was to be subsequently placed. The relation of the temperature of incandescent platinum to the amount of light emitted by it was also examined, and it was found, photometrically, that at 2,590° F. the light emitted was more than thirty-six times as much as that given out by the same strip of metal at 1,900°. Moreover, on measuring, by means of the thermo-pile, the total energy radiated from the incandescent strip, he found that if he took the heat radiated at 980° as unity, that emitted at 2,360° was 17.8; the heat radiated between 1,000° and 1,300° being nearly the same in amount as that radiated in passing from common temperatures up to 1,000°. In closing this memoir the author says: "The preceding experiments furnish an easy means of supplying * * * what might be termed a 'unit lamp.' A surface of platinum of standard dimensions, raised to a standard temperature by a voltaic current, will always emit a constant light.

A strip of that metal one inch long and one-twentieth of an inch wide, connected with a lever by which its expansion might be measured, would yield at 2,000° a light suitable for most purposes. Moreover, it would be very easy to form from it a photometer by screening portions of the shining surface. An ingenious artist would have very little difficulty, by taking advantage of the movements of the lever, in making a self-acting apparatus, in which the platinum should be maintained at a uniform temperature, notwithstanding any change taking place in the voltaic current."

In the following year Dr. Draper published a noteworthy memoir on the production of light by chemical action. In this memoir he investigates by means of the prism the character of the light which is produced by combustion, answering thus his own query, "Can any connection be traced between the chemical nature of a substance or the conditions under which it burns and the nature of the light which it emits?" With a slit, a prism, and an observing telescope he examined the flames of oil, of alcohol, of alcoholic solutions of boric acid and strontium nitrate, of phosphorus, of sulphur, of carbonic oxide, of hydrogen, of cyanogen, and of arsenetted hydrogen. The flame of the oil was yellow; of the alcohol, pale blue; of the boric acid, green; of the strontium, red; of the phosphorus, yellowish white; of the sulphur and carbonic oxide, blue; of the hydrogen, pale yellow; of the cyanogen, lilac, and of the arsenetted hydrogen, white. "Notwithstanding this diversity of color," he says, "all these flames, as well as many others that I have tried, yield the same result; every prismatic color is found in them. Even in those cases where the flame is very faint, as in alcohol and in hydrogen gas, not only may red, yellow, green, blue, and violet light be traced, but even bright Fraunhoferian lines of different colors." The spectra given by these variously-colored flames were carefully drawn and their peculiarities were pointed out. When he thus examined the flame of cyanogen he beheld, as he says, "a spectrum so beautiful that it is impossible to describe it by words or depict it in colors. It was crossed throughout its extent by black lines separating it into well-marked divisions. I could plainly count four red rays of definite refrangibility, followed by one orange, one yellow, and seven green rays, while in the more refrangible spaces were two extensive groups of black lines, recalling somewhat from their position, but greatly exceeding in extent, Fraunhofer's lines G and H in the sun's rays." He considered the interior lilac cone to be

the source of the fixed lines of the bright spectrum, and he observed that new lines are developed as the temperature rises. "Do not the various facts here brought forward," he says, "prove that chemical combinations are attended by a rapid vibratory motion of the particles of the combining bodies, which vibrations become more frequent as the chemical action is more intense?" This memoir may be regarded as one of the earliest contributions to spectrum analysis.

In a subsequent memoir, written in 1857, Dr. Draper uses the following remarkable language: "In other cases dark lines are replaced by bright ones, as in the well-known instance of the electric spark between metallic electrodes. *The occurrence of lines, whether bright or dark, is hence connected with the chemical nature of the substance producing the flame.* For this reason these lines merit a much more critical examination, for by their aid we may be able to ascertain points of great interest in other departments of science. Thus, if we are ever able to acquire certain knowledge respecting the physical state of the sun and other stars, it will be by an examination of the light they emit." Surely these researches, with the prophetic conclusions which he drew from them, entitle Professor Draper to a recognized position among the pioneers in the science of prismatic analysis.

Some of the earliest of Dr. Draper's investigations were directed to a determination of the various forms of energy which exist in solar light. The chemical action of light was always a fascinating subject to him and he had made many interesting experiments to ascertain the effect of different kinds of light upon chemical change. These chemical actions were investigated in three different directions. The first of these was photography. For many years he had studied the action of light in changing the color of metallic salts, and he had already long been accustomed to apply the photographic process to the solution of physical problems when Daguerre's discovery was announced in 1839. He welcomed the daguerreotype enthusiastically, made a special study of it, and in the same year improved it so much that he took by its means the first portrait of the human face. In these days of rapid emulsion processes the directions he gives for taking a daguerreotype appear interesting. "In the first experiments I made," he says, "the face of the sitter was dusted with a white powder, but a few trials showed that this was unnecessary." "On a bright day and with a sensitive plate portraits can be obtained in the course of five or seven minutes in the

diffused daylight even when an ammonia-sulphate of copper cell is interposed. The hands should never rest upon the chest, for the motion of respiration disturbs them so much as to make them of a thick and clumsy appearance, destroying also the representation of the veins on the back, which, if they are held motionless, are copied with surprising beauty. A person dressed in a black coat and open waistcoat of the same color must put on a temporary front of a drab or flesh color, or by the time that his face and the fine shadows of his woolen clothing are evolved his shirt will be solarized and be blue or even black, with a white halo around it. Owing to the circumstance that yellow and yellowish browns require a long time to impress the substance of the daguerreotype persons whose faces are freckled all over give rise to the most ludicrous results—a white portrait mottled with just as many black dots as the sitter has yellow ones." On the 23d of March, 1840, Dr. Draper presented to the Lyceum of Natural History of New York the first representation of the moon's surface ever taken by photography. The daguerreotype plate was exposed twenty minutes and the image was about an inch in diameter. In this image the places of the dark spots can be indistinctly traced.

The second method by which he studied the action of the chemical rays was based upon the effect which they produced upon chlorine gas. In 1843 he announced to the British Association that this gas underwent a decided modification under the influence of sunlight, in consequence of the absorption of these chemical rays. In virtue of this change in its character it was now able to unite directly with hydrogen, a property not possessed by chlorine kept in the dark. Hence he announced the discovery of a new imponderable in solar light which was analogous to light and heat, and which was the agent producing chemical change. To this new agent he gave the name "tithonicity," the origin of which he thus describes: "The chemical rays are associated with the rays of light, accompanying them in all their movements, originating with them, and, unless disturbed, continuing to exist along with them. But should a compound beam like this fall upon a sensitive surface the chemical rays sink into it, as it were, and lose all their force, and the rays of light are left alone. Photographic results thus obtained from the reposing of the chemical rays on the sensitive surface are not, however, in themselves durable, for the rays escape away under some new form. Tithonus was a beautiful youth whom Aurora fell in love

with and married in heaven. The fates had made him immortal; but, unlike his bride, in the course of events he became feeble and decrepit, and, losing all his strength, was rocked to sleep in a cradle. The goddess, pitying his condition, metamorphosed him into a grasshopper. The fact and the fable agree pretty well, and, indeed, the playful coincidence might be carried much farther. The powers of photography, which bring architectural remains and the forms of statuary so beautifully and impressively before us, might seem to be prefigured by the speaking image of the son of Tithonus and Aurora that was to be seen in the deserts of Egypt. Besides this such words as tithonoscope, tithonometer, tithonography, tithonic effect, dititho nescence are musical in an English ear." In the same year he described a tithonometer or instrument for measuring these chemical rays based on their action upon chlorine. The apparatus consisted of an inverted siphon tube, the shorter limb of which was closed, the longer drawn out and graduated. By means of wires of platinum sealed into the shorter limb the solution of hydrochloric acid which it contained could be decomposed by a voltaic current, and this limb filled with mixed hydrogen and chlorine gases. When the image of a flame, formed by a convex lens, was caused to fall on the sentient tube the liquid in the longer limb began instantly to descend, moving regularly over the scale so long as the exposure was continued. This instrument, while much simpler, appears to be quite as sensitive as the one described by Bunsen and Roscoe many years later (1856).

The third method which Dr. Draper employed for studying the action of the chemical rays was based on the growth of plants. Already, in 1837, he had investigated the phenomenon of the decomposition of solar light by leaves, and had shown that these leaves absorbed certain rays. But these early experiments were made under colored glasses and were not entirely conclusive, other rays passing simultaneously through the media used. When seeds were made to germinate under these glasses, however, he found that the plants under the red and the violet glasses were as perfectly etiolated as if they had been kept in the dark; while those under the yellow glass promptly assumed a green color and developed rapidly. In order to obviate the objection raised to colored glasses a crop of seeds was caused to germinate in a long box placed in the dark and the young plants were then exposed to the action of a solar spectrum. Those in the yellow speedily turned green, while those in the red

and in the violet regions remained unaffected. An attempt was then successfully made to effect the decomposition of carbonic-acid by the green parts of plants also placed in the solar spectrum. Water freed from air by boiling was saturated with carbonic acid gas, and in it was immersed grass whose surfaces had been carefully freed of air. Seven tubes thus prepared were placed each in one of the seven colors of the spectrum and carefully observed. In a few minutes after the beginning of the experiment the tubes on which the orange, the green, and the yellow rays fell began to give off minute bubbles of gas, and in an hour and a half sufficient was collected for accurate measurement. Forty-three volumes of gas were produced in the yellow-green, twenty-four and three-fourth volumes in the red-orange, four and one-tenth in the green-blue, one in the blue, and none in the other colors. The memoir in which these results were first published was read to the American Philosophical Society on the occasion of its centennial anniversary in 1843.

But it was mainly by means of spectrum investigations that Dr. Draper studied the components of radiant energy. In the earlier stages of his work he, in common with his contemporaries, regarded heat and light as imponderable agents, entirely distinct from one another, though coexisting in solar light. In his later memoirs, however, having accepted the essential unity of radiant energy, he discusses with great ability, in his memoir of 1872, on the distribution of the chemical force in the spectrum, the dependence of the result upon the nature of the surface upon which the light falls. In this memoir he shows: First, that so far from chemical influences being restricted to the more refrangible rays every part of the spectrum, visible and invisible, can produce chemical changes and can modify the molecular arrangement of bodies; and, second, that the rays effective in producing chemical or molecular changes in any special substance are determined solely by the absorptive power of that substance. Thus silver salts, for example, blacken most readily in the more refrangible regions. But even these have their peculiarities. An iodide of silver plate long exposed to the spectrum, with absolute exclusion of extraneous light, is normally darkened in the more refrangible and receives a white stain in the less refrangible regions. If, however, the plate receive weak diffused light during exposure it will be found on developing that every ray that the prism can transmit, from below the extreme red to beyond the extreme violet, has been active. Indeed, it was by this very process

that Dr. Draper, in 1843, discovered the dark lines α, β, γ in the ultra-red. Essentially the same results are obtained if the plate is submitted to a weak light for a few moments previous to its exposure to the spectrum. It would seem, therefore, as if the less refrangible rays could reverse the general action of light upon iodide of silver. So that, while every ray of the spectrum is capable of affecting this substance, the more refrangible promote, the less refrangible arrest, this general action of light upon it.

Bitumen and resins also receive impressions from below A to beyond H, every ray in the spectrum acting. In the bleaching of flowers by light "the rays which are effective in the destruction of any one vegetable color are precisely those which by their union produce a tint complementary to the color destroyed." Chlorine and hydrogen unite under the action of the indigo ray, which is seven hundred times more active than the ultra-red. Dr. Draper concludes, therefore, "that the sensitiveness of any given preparation to light depends on its chemical nature and its optical qualities conjointly, and that it is possible to exalt or diminish the sensitiveness of a given compound by changing its optical relations."

The results of Dr. Draper's investigations with the prismatic spectrum, however, were not altogether satisfactory to him, owing to a defect which originates in the very cause which gives rise to the spectrum itself—unequal refrangibility. If we compare together two sets of rays, one taken in the red and the other in the violet region, it is obvious that, in the same spectrum, from the very circumstance of their greater refrangibility, those in the violet will be relatively more separated from each other than those in the red. The result of this increased separation in the more refrangible regions is to give an apparent dilution to them, while the less refrangible regions are concentrated.

Accordingly, in May, 1843, Dr. Draper succeeded in inducing Joseph Saxton, the eminent mechanician of the United States mint at Philadelphia, to rule for him a diffraction grating. With this grating, which was of glass and five-eighths of an inch by one-third of an inch in size, the diffraction spectrum was produced and the above difficulties avoided. Dr. Draper effected a great improvement in the grating by silvering its ruled surface with tin amalgam, thus producing a reflected spectrum which was far more brilliant than the transmitted one, though he suggested that perhaps it would be better to rule them originally on steel or speculum metal. It

was at this time, too, that Dr. Draper suggested that the different regions of the spectrum should be indicated by their wave-lengths. "Since the deviations of the different fixed lines, B, C, D, in the interference spectrum," he says, "are proportional to the lengths of the undulations which they respectively represent, by designating the different points of the spectrum by their wave-lengths, the subdivision may be carried to any degree of minuteness; the measures of one author will compare with those of another and the different phenomena of chemical changes occurring through the agency of light become allied at once with a multitude of other optical results."

It was with this grating that the diffraction spectrum was for the first time photographed. A daguerreotype plate, rendered sensitive by iodine and then by bromine, and exposed for half an hour, gave a maximum sensitiveness at wave-length 0.00001538 Paris inch. A plate prepared by iodine, bromine, and chloride of iodine, and exposed for an hour, gave a maximum at the same point, the decomposition extending from wave-length 0.00002007 in the green to 0.00001257 in the violet. In these photographs the fixed lines were beautifully distinct.

Dr. Draper, too, was among the first to point out the unsatisfactory character of the measurements which have been made with the prismatic spectrum on the distribution of heat. Since the less refrangible regions are much compressed and the more refrangible much dilated, the measures obtained by means of a uniform movement through the spectrum cannot be accepted as expressing the true distribution. Hence, in 1857, he attempted to determine the curve of distribution in a diffraction spectrum; but the results, though suggestive, were not conclusive. Subsequently, in 1872, he devised a simple modification of the prismatic spectrum method, which accomplished practically the result which he had desired to obtain with the interference spectrum. Using Angström's values expressed in ten millionths of a millimeter, the wave length of the line A is 7,604 and that of H_2 3,933, these lines bounding very nearly the visible spectrum. The middle point is, therefore, at 5,768. If, now, the heat be determined first in the region from 7,604 to 5,768, and then from 5,768 to 3,933, may not the question of its uniform distribution be thus settled? Upon making the experiment it was found that the two halves of the spectrum gave identically the same amount of heat, and this whatever be the material of the prisms.

Hence it follows that any two series of undulations in the spectrum will have the same heating power, no matter what their wave-lengths may be.

Continuing his spectrum investigations, Dr. Draper next sought to determine the law of the distribution of light. Mosotti, in Italy, had already studied the diffraction spectrum, and had shown that the maximum of illuminating power lay in the yellow, the intensity declining symmetrically on either side. The photometric method of Bouguer Dr. Draper had used in 1847, with good results, to measure the intensity of the light radiated from incandescing platinum; and he now, in 1879, sought to construct a spectrometer on the same principle which should measure light-intensity. The principle is a well-recognized one in optics. It is that any light becomes invisible in presence of another light sixty-four times as strong. If, as Mosotti had maintained, the yellow be the brightest of the spectrum colors, then in presence of an extraneous light thrown on the spectrum and variable at will, the yellow will remain after the red and orange on the one side, and the green, blue, and violet on the other, have been extinguished. But on making the experiment, throwing the extinguishing white light through the third telescope of an ordinary spectroscope, so as to reflect it to the eye from the face of the prism, Dr. Draper found that the colors of a gas-flame spectrum disappeared in the inverse order of their refrangibility, the red being the last to disappear. Analogous experiments with the spectrum of sunlight, which was sometimes thrown on a screen and sometimes on the ground glass of a camera and extinguished by daylight, gave precisely similar results. On gradually opening the shutter admitting the daylight, the extreme violet disappeared first, and then the other colors in the inverse order of refrangibility as before. On closing the shutter the red first came into view, and then the other colors successively. Obviously, if this result is due to the compression at the red end of the prismatic spectrum, then it should not be found in that produced by diffraction; and on making the experiment Dr. Draper saw, not without pleasure, that as the intensity of the extinguishing beam increased all the colored spaces yielded apparently in an equal manner and disappeared at the same moment. On diminishing the intensity of the extraneous light he observed that they all came into view apparently at the same time. The yellow, as before, showed no superiority over the other colors in resisting extinction. It would seem, therefore, that

the apparent brightness of the yellow, as seen by the eye, is a purely physiological phenomenon.

Another subject to which Dr. Draper devoted a large share of attention was phosphorescence. In his first memoir on this subject, published in 1851, he discusses the general character of the phenomenon, and restricts the term phosphorescent to those bodies which shine in the dark after exposure to light or on being heated. Fluor-spar, of the variety known as chlorophane, which yields a superb emerald-green light, was selected for experiment. He found that when made to phosphoresce by the electric spark it underwent neither expansion nor contraction, nor any other molecular change detectable in polarized light. He did observe a minute evolution of heat, but could detect no electrical change. Nor did the presence of a powerful magnetic field appear to affect the result. On measuring the amount of light emitted it appeared that this splendid green light was photographically twenty-four times, and photometrically three thousand times, less intense than that of the small flame of an oil lamp taken for comparison. But he noticed that the quantity of light emitted by a phosphorescent body was proportional to the intensity of the light to which it had been exposed. In 1844 Dr. Draper determined that the special phosphorogenic rays of the spectrum were the violet rays. In this research he used a quartz train and threw the spectrum upon a screen covered with calcium sulphide. He observed, further, that for the transient light of the spark quartz is transparent but glass is opaque—that is, so far as a surface of calcium sulphide is concerned, though not a sensitive silver surface. Moreover, while glass is opaque to phosphorogenic rays from the spark, it transmits freely those from incandescent lime, so that the calcium light, the light of an oil lamp, and sunlight can excite phosphorescence through glass; that of the electric spark or of the voltaic discharge in mercury cannot. If, however, the latter be continuous an effect is produced even through glass.

In his last scientific memoir, published near the close of 1880, Dr. Draper called attention to the striking resemblance existing between a photograph of the solar spectrum taken on silver iodide and a phosphorograph taken on luminous paint. The former, when taken in presence of a weak extraneous light, shows the three regions which were pointed out by him in 1842: (1), a middle region, extending from the boundary of the green and blue to a little beyond the violet; here the silver iodide is blackened; (2), below this

and extending from the green to the ultra-red is a strongly-marked region in which the action of daylight has been altogether arrested or removed, the daylight and the sunlight having apparently counterbalanced and checked one another; and (3), a similarly protected region, much shorter, beyond the violet. The phosphorograph, in the absence of extraneous light, shows a shining region corresponding to number one of the photograph. But if foreign light intervenes there is annexed to this region another, including the less refrangible spaces, of decided blackness, broken, however, at a short distance below the red by a luminous rectangle of considerable width, formed by the coalescence of the bands α, β, γ. There is also a similar but smaller region in the violet. In this memoir Dr. Draper notices the rapidity with which the red spectrum rays extinguish phosphorescence.

The electrical investigations which were undertaken by Professor Draper were much fewer in number than those on light. One of the most important of these was a paper on the electromotive power of heat, published in 1840, in which he discusses the electromotive force developed in pairs of different metals as the temperature rises and gives values for wires of copper-iron, silver-palladium, iron-palladium, platinum-copper, iron-silver, and iron-platinum, obtained with one junction kept at 32° and the other raised either to 212° or to 662°F. He gives curves of the thermo-electric action of these metals, the abscissas being temperatures and the electromotive forces ordinates, constituting a thermo-electric diagram. In this diagram the curves of iron-palladium and copper-silver are concave toward the axis of abscissas, while those of iron-platinum, copper-platinum, and silver-palladium are convex toward this axis. He observed also that the increase of electromotive force with temperature differed for the different pairs. He calls attention to the anomalous results which are given by pairs into which iron enters, and gives the diagram of a copper-iron couple, the maximum ordinate of which is at 650° and the neutral point at a temperature at which an alloy of equal parts of brass and silver melts. The paper concludes with several suggestions in regard to the forms which it is desirable to give to the components of a thermo-electric couple.

In 1834 he studied the action of the galvanic battery and published an account of some improvements in its construction which his experiments had suggested. In 1835 he repeated the experiments of Morichini and Mrs. Somerville on the reputed magnetiz-

ing effect of violet light, and came to the conclusion that there was no evidence whatever to sustain the opinions of these experimenters. In 1839 he published a somewhat extended paper on the use of a secondary wire as a measure of the relative tension of electric currents, describing the construction and use of a torsion galvanometer and discussing a method of measuring electro-motive force by the fall in the deflection when a wire of high resistance was included in the circuit. He also considers in this paper the relations of electro-motive force and of resistance to the current produced. In 1843 a paper on the law of the conducting power of wires gave the results of his measurements made to solve the problem of transmitting electric impulses through long lengths of a conductor, a research undertaken to aid his colleague, Professor Morse, in perfecting his electro-magnetic telegraph. In this paper the author shows that the diminution of the strength of an electric current itself diminishes rapidly with increase of length in the wire, and that generally the conducting effect of wires may be represented by a logarithmic curve.

The purely chemical researches published by Dr. Draper were also few in number. Among these may be mentioned his memoirs on the analysis of certain ancient coins and medals (which seemed to him to prove the possibility of diffusion in solids) on micro-chemistry, on the constitution of the atmosphere, on respiration, on the allotropism of chlorine, on the existence and effects of allotropism in the constituent elements of living beings, on a singular property of gun-cotton mixture, and on a new method for the determination of urea.

In 1844, in a volume on the forces which produce the organization of plants, Dr. Draper published, as an appendix, the scientific memoirs of his which had appeared up to that time bearing on this question, and in 1873, in a book entitled "Scientific Memoirs," he collected together the papers which he had published upon Radiant Energy and closely allied subjects.

During the later years of his life Professor Draper devoted his time much more largely to literary than to scientific work. Upon his appointment to the chair of physiology in 1850 he turned his attention once more to physiological subjects, and in 1856 he collected together the matter which he had carefully elaborated in his class lectures into his "Human Physiology, Statical and Dynamical." This book marked a new departure in the science of physiology,

since it contained not only the results of his valuable original investigations on various important subjects, illustrated by his own admirable micro-photographs, but also clear and forcible discussions of the applications of strictly scientific theory to a region heretofore almost entirely given over to a hypothetical vital force. "Among the new experiments and explorations which it contained may be mentioned the condensing action of membranes, the cause of the coagulation of the blood, the theory of the circulation of the blood, the explanation of the flow of sap, the endosmotic action of thin films, the measure of the force of endosmose, the respiration of fishes, the action of the organic muscle-fibers of the lungs, the allotropism of living systems, the action of the skin, the functions of the nerve vesicles and their electrical analogies, the functions of the sympathetic nerve, the explanation of certain parts of the auditory apparatus, particularly of the cochlea and semicircular canals, the theory of vision, and the theory of muscular contraction." This treatise took at once a recognized rank as a text-book, both in this and other countries, and was translated into several foreign languages, and even into Russian.

Perhaps it was quite natural that a philosophic mind like Draper's should be led by these studies to formulate a sort of socialistic physiology and to trace in the working of communities and nations the same laws which control the evolution of the individual. But however this may be the "Physiology" was followed, in the course of a few years, by what many have considered his most brilliant work, "A History of the Intellectual Development of Europe," published in 1863. "The object of this work was mainly to point out that the intellectual progress of nations proceeds in the same course as the intellectual development of the individual; that the movement of both is not fortuitous, but under the dominion of law; that the stages of personal development are paralleled by the stages of social development, and, indeed, as paleontology has proved, by the evolution of all animated nature, and that there is an ascent of man through well-marked epochs from the most barbarous to the most highly civilized condition." In short it was designed to be an argument in favor of evolution and the reign of law in the historical development of the world. Few philosophical works have attained to celebrity so quickly. It ran rapidly through many editions in this country and was translated into nearly every European language. *The Westminster Review* said of it: "It is one of the not

least remarkable achievements in the progress of positive philosophy that has yet been made in the English tongue—a noble and even magnificent attempt to frame an induction of all the recorded phenomena of European, Asiatic, and North African history. Unaccustomed though a reader might be to scientific habits of thought or uninterested in the gradual elaboration of eternal rules and principles, here he can at least disport himself amid noble galleries of historic paintings and thrill again at the visions of the touching epochs that go to form the drama of the mighty European past. What Comte showed might and ought to be done for the whole world of man; what Buckle commenced for England, Scotland, France, and Spain, Draper has effected for the whole of Europe. The gigantic vastness of the task is almost paralyzing." So too the *Athenæum*: "It is no light commendation to say that its execution is not altogether unequal to its magnitude. If it were equal the world would place Dr. Draper on one of the very highest pinnacles of intellectual achievements. His tenacity and completeness of grasp makes itself felt for the most part on every page."

In 1864 the Historical Society of New York invited Dr. Draper to deliver a course of four lectures upon some subject in general political economy. These lectures were afterward expanded and published the following year under the title, "Thoughts on the Future Civil Policy of America." They treated: (1) on the influence of climate upon man; (2) on the effects of emigration; (3) on the political force of ideas, and (4) on the natural course of national development. These lectures "contained discussions of several interesting points which since that time have largely occupied public attention, such as the internal emigration from the Atlantic States to the West, the Asiatic emigration to the Pacific States, the political effects of polygamy in Utah, the tendency of democratic institutions to centralization, and a comparison of the European with the American method of government."

The line of investigation thus entered upon resulted in his undertaking a far more serious labor, the preparation of a "History of the American Civil War," a work upon which he was almost continuously engaged for several years immediately following the close of this war, and which appeared in three large volumes during the years between 1867 and 1870. He had been urged to enter upon this work by the earnest request of persons who had been chief actors in the events described and who rendered him effective aid.

Mr. Stanton, the Secretary of War, issued orders to the adjutant general of the army of the United States to "furnish him copies of all orders, reports, correspondence, telegraphic dispatches, or other documents on file in the War Department as he might request, and to permit him to inspect and have copies of any maps, plans, and other papers necessary for the preparation of his work, and to furnish him with statistical information respecting the armies of the United States, their organization and operations." This order included also all the Confederate archives in possession of the War Department. Nor was the interest of the Secretary of War limited to this. He supplied a large amount of personal information of the utmost value. Access was not unfrequently given the author to documents and correspondence of the most confidential kind, with a view of guiding him to correct conclusions; and many of the most decisive military operations are detailed from private memoranda furnished by the commanding officers themselves.

The last literary work on which Dr. Draper was engaged was the "History of the Conflict between Religion and Science," issued in 1874 as one of the volumes of the International Scientific series. Much of the material utilized in this volume is said to have been matter originally intended for the "Intellectual Development of Europe." The book attempted to trace the development of the antagonism which has ever been present between the conservative and the scientific elements of thought, between the ecclesiastical and old on the one side and the radical and new on the other. The former, always opposed to the progress of the latter, has sought in all times to hinder this progress by every means it could devise lest forsooth some of its antiquated tenets should require modification. The title of the book has sometimes been criticised on the ground that religion is a personal element entirely, and with this, of course, science can never be in antagonism. But using the word in the broader sense, in which Dr. Draper used it—as synonymous with ecclesiasticism and theology—there always has been a conflict between them and there always will be so long as they both shall exist. The favor with which this book was received was something surprising. In the first ten years of its existence it passed through more than twenty editions in the English language and was translated into French, Spanish, German, Dutch, Russian, Italian, Portuguese, Polish, and Servian. It has even been placed on the Index Expurgatorius of the Romish church, an honor which its author has

shared with Galileo, with Copernicus, with Kepler, with Locke, and with Mill.

In all his literary work Dr. Draper's methods were always of the same high character as those which distinguished his scientific investigations. He showed alike in both the same close and impartial scrutiny of the facts, the same careful and minute examination of all the conditions which they involved, the same conscientious and exact record of the results obtained. After passing the ordeal of his severe criticism his work had little to fear from outside attack. All that he did was pervaded by the high moral tone which characterized the man. If he was scrupulously accurate in observing and testing his facts and in drawing inferences from them, if he was ingenious in devising and skillful in applying crucial tests to detect error or misconception, he was equally honest in placing his observations and conclusions on record and in according to his contemporaries and co-workers the full share of praise to which they were entitled.

It is not easy to estimate the value of Dr. Draper's services as a teacher. From the time of his appointment to the professorship in Hampden Sidney College in 1836 until the year before his death—a period of forty-five years—he was constantly occupied in the work of instruction. Of the facilities at his disposal when he first went to New York he thus speaks: "Our laboratory was then in a little dark back room without ventilation. The morning sun struggled almost in vain to see what we were doing, for the window-panes were covered with an incongruous arrangement of Venetian blinds and Gothic mullions. A hole in the ceiling led up to the chapel above, to the pulpit of which the material for the daily lecture was carried in a tea-tray. I called it a pulpit, because they used to preach out of it. A clergyman, who also statedly occupied it, regarded it as a pneumatic trough, because I experimented in it. And this, I think, it really was, for, recalling the Greek etymology of that epithet, it plainly indicates the double function, spiritual as well as chemical. Our laboratory work commenced at seven in the morning and continued uninterruptedly till after midnight, and, as might have been readily foreseen, what, with the impure air and mental application, the individual chiefly engaged twice contracted a fever and narrowly escaped with his life." During the ten years from 1840 to 1850 he gave a series of introductory lectures to the medical classes in the university, which are among the best popular

expositions of the applications of science to medicine to be found in the language. These, as well as his valedictory lectures, were generally printed by the classes to which they were severally addressed. According to competent authority they were "clear in statement, fresh and striking in their views, and lively, poetic, and witty, as well as instructive, well fitted to awaken the students' enthusiasm." Those on the relations of chemistry to medicine, on the history of chemistry, on atmospheric air, on water, on oxygen, and on phosphorus are spoken of as having been exceptionally suggestive and brilliant.

Dr. Draper appeared but rarely upon the platform of the public lecturer. In 1853 he made an address before the Alumni Association upon "The Indebtedness of the City of New York to its University," which was a strong plea for science in education. In 1863 he gave the anniversary discourse before the New York Academy of Medicine, the subject of which was "The Historical Influence of the Medical Profession." His lectures before the Historical Society in 1864 have already been mentioned. As president he addressed the American Union Academy at its first annual meeting in 1870. His felicitous address at the farewell dinner to Professor Tyndall, given in New York in February, 1873, and his inaugural address as president of the American Chemical Society on "Science in America," delivered in 1876, are among his happiest efforts. One of the most noteworthy of his public addresses was that upon Evolution, delivered before the Unitarian Institute, in Springfield, in October, 1877.

Besides the work which Dr. Draper did in pure science he was closely connected with the development of two of the most important inventions ever made. One of these was the electro-magnetic telegraph of Morse, the other was the art of photography. In one of his addresses to the alumni (1853) he gives the following account of the evolution of the telegraph: "Fourteen years ago there stood upon the floor of the chemical laboratory of our University a pair of old-fashioned galvanic batteries. Like the cradle of a baby, they worked upon rockers, that so the acid might be turned on or off. A gray-haired gentleman had been using them for many years to see whether he could produce enough magnetism in a piece of iron at a distance, to move a pencil and make marks upon paper. He had contrived a brass instrument that had keys something like a piano in miniature, only there was engraven on each a letter of the

alphabet. When these were touched the influence of the batteries was sent through a copper wire and a mark answering to a letter was made a long way off. * * * But long after the telegraphic instruments were perfected it was doubtful whether intelligence could be sent to any considerable distance. It is one thing to send an electric current a few yards and a totally different affair to send it a thousand miles. Experiments which had been made under the auspices of the Russian government by Professor Jacobi, of the University of Dorpat, had led to the inference that the law of the conducting power of wires, originally discovered in Germany, was correct; and, in addition, a corroborative memoir had been read by Lenz before the Imperial Academy of Sciences at St. Petersburg. At this time so little was known in England as regards this important point, that some of the most eminent natural philosophers connected with universities there embraced the opposite view. I may not be able to make the precise point in dispute clear; it was this: A current passing through a certain length of wire suffers a certain amount of loss. If it should go through a wire a thousand times as long will the loss be a thousand times as great? The Russians said yes; the English said no. If the former was the case it was universally concluded that the electric telegraph would not be practicable for any considerable distance. A series of experiments was made in the University of New York which established beyond all question the truth of the Russian view. But at that time the higher mathematics were cultivated in our laboratory, as well as mere experimenting; and on submitting the results to such a mathematical discussion the paradoxical conclusion was brought out that it is a necessary consequence of that law that after a certain length of wire has been used the losses become imperceptible. Encouraged by this, a party of gentlemen went with the inventor of the telegraph to a rope-walk near Bloomingdale, one summer morning, and there tested the truth of these conclusions on lengths of wire varying from one to some hundreds of miles. The losses of the currents were measured by the quantity of gas set free in the decomposition of water. The result was completely successful, and telegraphing for any distance became an established certainty."

The part which he took in the evolution of photography he thus describes: "When the French government, in 1839, purchased of Daguerre his invention of photogenic drawing, its applications were very limited. The process was adapted to interiors, statuary, and

architectural subjects, but wholly unsuited to landscape scenery or to portraits. The inventor himself had made attempts at applying it to the taking of likenesses, but had given it up in despair. Soon after the publication of Daguerre's invention in America a series of experiments was conducted in our laboratory with a view of determining whether the difficulties could be removed." The results were successful, and the taking of portraits from life by daguerreotype became before long an everyday operation.

The great value of Dr. Draper's contributions to science has been cordially recognized by the highest authorities. Melloni, the creator, as it were, of the science of radiant heat, warmly congratulated him on his memoir on this subject, presented an abstract of it to the Royal Academy of Sciences at Naples, and in his own subsequent memoir warmly commends the ingenuity and ability of the American scientist. Herschel was equally cordial in praise of his photochemical researches. Berzelius, a few days before his death, sent to Dr. Draper his portrait with a kind message conveying his appreciation of what he had done for science. Kirchhoff, in 1862, thus speaks of his heat experiments: "Draper has derived from experiment the conclusion that all solid bodies begin to glow at the same temperature, but he has observed in his experiments that certain bodies, as chalk, marble, and fluor-spar, shine at a lower temperature than they should according to this law; he calls this light phosphorescent and observes that it is distinguished from the glow by its color. But whatever name may be given to the light it contradicts the law, and a body which shows it cannot satisfy the assumption which is made in proving the law; it cannot remain unchanged, the temperature remaining the same; the phosphorescence is not the simple influence of heat, it is not exclusively conditioned on temperature, but it is caused by changes in the body; if these changes, be they chemical or of any other kind, cease, then the phosphorescence must also vanish." Bunsen and Roscoe have recognized Dr. Draper most fully as the pioneer in the investigation of the action of light upon chlorine, a subject worked out successfully by them.

Dr. Draper was elected a member of many of the learned societies of Europe, among them the Accademia dei Lincei, at Rome, and the Physical Society of London. In 1843 he was elected a member of the American Philosophical Society at Philadelphia, and in 1860 he received the degree of LL. D. from the college of New

Jersey at Princeton. In 1875 the American Academy of Arts and Sciences at Boston awarded to him the Rumford medals for his reseaches on Radiant Energy. In his speech of presentation the Hon. Charles Francis Adams, then president of the Academy, after recapitulating the reasons given by the committee for recommending this award, said to Mr. Quincy, who was deputed in Dr. Draper's absence to receive the medals: "I pray you, in receiving these two medals on his behalf, in accordance with the terms of the original trust, to assure him on the part of the Academy of the high satisfaction taken by all its Fellows in doing honor to those who, like him, take a prominent rank in the advance of science throughout the world." In his letter of reply Dr. Draper says: "Your favorable appreciation of my researches on radiation, expressed today by the award of the Rumford medals—the highest testimonial of approbation that American science has to bestow on those who have devoted themselves to the enlargement of knowledge—is to me a most acceptable return for the attention I have given to that subject through a period of more than forty years. * * * It adds impressively to the honor you have this day day conferred on me that your action is the deliberate determination of competent, severe, impartial judges. I cannot adequately express my feelings of gratitude in such a presence, publicly pronouncing its approval of what I have done."

Professor Draper was not elected a member of the National Academy of Sciences until 1877. It is not easy to understand at this late day why a man so eminent in science was not included among the original incorporators of the Academy. An attempt, it is believed, was made to remedy this apparent oversight during the meeting which was held in New York in 1863 for organization, but for some unexplained reason the effort failed. So uncalled for an action on the part of the Academy rendered it for some time doubtful whether he would accept the membership when it was subsequently tendered.

Dr. Draper was married at quite an early age. While a student at the University of London in the year 1830, then nineteen years old, he boarded with a friend of his father's, Mrs. Barker by name, where he met her niece, Miss Antonia Gardner, who was then residing with her and attending a young ladies' school in the neighborhood. This young lady was the daughter of Dr. Gardner, of Rio Janeiro, the attending physician of the Emperor of Brazil,

Dom Pedro I. Though himself an Englishman Dr Gardner had married into the celebrated de Piva-Pereira family of Portugal, and this, their only daughter, had been brought to London to complete her education. Within a few months they became engaged, and in 1831, not long after the death of her father, in Brazil, they were married. In 1832 Dr. Draper's father also died, and his mother accompanied the newly-married couple across the ocean to settle among the little Wesleyan colony in Virginia, where she died in the following year. It was to his accomplished wife that Dr. Draper owed much of the happiness which characterized his married life. Six children were born to them, one of whom died in infancy. The eldest son, John Christopher Draper, was born in Virginia in 1835 and became his father's successor as professor of chemistry in the medical department of the University of New York. He died on the 20th of December, 1885. The second son, Henry Draper, was born in 1837 also in Virginia. He became professor of physiology in the university and subsequently professor of analytical chemistry. He early turned his attention in the direction of physical research, especially in its application to astronomy, and was elected a member of the National Academy in 1877. His early death in 1882 alone prevented his rising to an equal eminence as an investigator with that attained by his distinguished father. The third son, Daniel Draper, is at present the director of the Meteorological Observatory in Central Park, New York. Dr. Draper's daughters were Virginia, afterward Mrs. Maury, named for the State in which she was born, who died in October, 1885, leaving three children; and Antonia, who is at present Mrs. Edward H. Dixon.

Any record of the Draper family, however, which did not mention Dr. Draper's elder sister Catherine would be quite incomplete. As already mentioned, she accompanied the newly-married couple across the ocean when they removed to America. Having shared her brother's tastes for scientific studies, she became his assistant in research and rendered him most valuable aid. Her portrait was the first ever taken from the life by the daguerreotype process, and the colored plates which illustrate his memoirs were the work of her pencil. She was a constant inmate in his family, and during the many years of Mrs. Draper's ill health she was as a mother to the children. She has outlived her brother, and resides still at the family mansion in Hastings.

On coming to New York Dr. Draper occupied at first a house in Charles street, subsequently removing to the corner of Broadway and Amity street. But in 1848 he purchased a delightfully located piece of property at Hastings upon the Hudson, where he lived until his death. It was here that Henry Draper built his observatory; and in this building the father and son spent many a pleasant hour together engaged in that most delightful of occupations, the pursuit of scientific knowledge.

Dr. Draper, though somewhat below the average stature, was a man of fine personal presence. He was mild in manner and quiet in demeanor, having very little of self-assertion. The excellence of his disposition and the charm of his personal intercourse drew to him warm and disinterested friends on every hand. He was an extensive reader and his conversational powers were remarkably developed, so that he always had attentive listeners, whether the subject of his discourse was literary or scientific. But it was when he opened his rich storehouse of personal reminiscence that his auditor was most charmed and delighted. His health, which through life had been generally good, was disturbed during his later years by severe attacks of gravel, which incapacitated him for journeying. These attacks wore upon him and finally ended his life. He died at Hastings, on the 4th of January, 1882, and was buried at Greenwood.

In the eloquent words of Professor Lovering, "Dr. Draper's mind was too large to be shut up within the walls of his laboratory. To him the minutest facts were of value, but only as they furnished the key for interpreting the Universal Cosmos of nature and humanity. In clear and graceful language the best that was in his thoughts was shared by the world. There was a continuity in his life-work, plain to himself, if not obvious to the superficial observer. He says: 'When I thus look back on the subjects that have occupied my attention I recognize how they have been interconnected, each preparing the way for its successor. Is it not true that for every person the course of life is along the line of least resistance, and that in this the movement of humanity is like the movement of material bodies?'"

PUBLICATIONS OF JOHN WILLIAM DRAPER.

I.—SCIENTIFIC MEMOIRS.

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* This must be a misprint for 1834, since at this date, in 1832, Draper had not yet left England.

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